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CORRECTIONS

DECEMBER, 1924, REVIEW:

Page 564, first column, line 23, for 3 read 1.

Page 566, second column, line 8, for *minimum* read *maximum*.

Page 569, table 2, July column, the exponent 2 should apply to 48.5 preceding.

Page 569, table 3, normal column, for 1.3 read 4.3, and for July 3.4 read 3.8.

JANUARY, 1925, REVIEW:

Table of Contents, second column, under heading "Charts," the Roman numeral "XIV" should be "XI;" at the end of the same line "14" should read "11".

Page 29, first column, fifth line of bold-faced type, in the name "Gorczynski" there should be an acute accent over the letter "n".

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CORONAS AND IRIDESCENT CLOUDS

By Charles F. Brooks

[Clark University, Worcester, Mass.] *

SYNOPSIS

Published observations and some new ones of coronas and iridescence are summarized to show (1) the essential facts about these diffraction phenomena, (2) the explanations for them, especially as to the limited part ice crystals may play in their formation, and (3) the relation between iridescence and cloud temperature.

Observations of coronas.—Coronas are the small colored rings frequently to be seen about the sun, moon, and, occasionally, bright stars or planets. The order of colors is such that blue is on the inside and red on the outside. Repetitions of the spectrum about the moon are observable, rarely, to a third red ring, but out from the sun at times brokenly to a fifth, and possibly a sixth or seventh red arc. Brilliant coronas can be observed in breath fog or on a befogged or frosted windowpane. The first red rings of coronas are most frequently from 1–5° from the sun or moon, but sizes down to 10′ from the edge of the moon, and up to 12° or 13° from the edge of the sun have been observed. Second rings, when seen beyond the first are usually at 70–100 per cent of the so-called radius, or distance of the first from the edge of the luminary. Third and fourth rings are commonly at irregular intervals greater than the radius of the first ring. Recognizable arcs of a fourth or fifth ring have been observed to about 30° from the sun, and of a second or third red ring to 11 or 12° from the moon. In about an eighth of the observations the corona is either distinctly noncircular or irregular, when cloud parts differing in stage of condensation or evaporation occur at the same angular distance from the luminary.

Observations of iridescence.—Iridescence on clouds is merely a mixture of portions of coronas of differing radii. Sometimes the mixture is regular, as in the banding parallel to the edge of a lenticular cloud. At others the mixture is irregular, as in the interior of a thin cloud of differing age or in wisps of fracto-cumulus. Iridescence may be seen about the moon at times to an angular distance of 12°, and about the sun to an angle of more than 57°, and even on the portion of the sky more or less opposite the sun. The brightest iridescences rarely extend to more than 30° from the sun. Lenticular clouds give the best displays, especially when they are forming and evaporating rapidly at low temperatures. As many as five spectra in succession, as marked by red bands, have been observed parallel to the rapidly forming edge of a lenticular cloud. Iridescence on fracto-cumulus wisps, while showing a connection with the rapidity of cloud formation and evaporation, is distinctly related to the temperature of the cloud. Extended brilliant iridescences occur only when the temperatures of this type of cloud are below about −5° C. A study of 38 cases showed that when iridescence extended to 20° or less from the sun the computed average cloud temperature was 3° C. and in no instance below −7° C.; when colors were visible to more than 20° but not over 30° the average was 0° C. and the coldest −13° C.; with coloring out more than 30° but not over 40° the average was −10° C. and the coldest −18° C., while with colors to more than 40° the average was −15° C. and the lowest −21° C. Iridescence on windowpanes covered with ice plates of frozen dew is of a different nature from the cloud iridescence.

Cause of coronas and iridescence.—Diffraction of light by small particles is the evident cause of coronas and iridescence. It seems probable that the particles involved are almost invariably water droplets, for the following reasons: (1) Brilliant coronas, glories, and iridescence have been observed on clouds known to be composed of water droplets, and, it seems, not on clouds known to have been exclusively of ice. (2) The most brilliant and widespread iridescence occurs on clouds forming and evaporating with a rapidity probably not possible for aggregates of ice crystals at temperatures so low as those where these clouds occur. (3) Liquid droplets have been observed at temperatures as low as those of most, if not all, iridescent clouds. Under rapid condensation at low temperatures such droplets seem more likely to form than ice crystals. Crystals, however, begin to form in such clouds of liquid droplets very soon, for lenticular iridescent clouds often transform quickly into distinctly different, noniridescent, sometimes halo-producing clouds of falling snow. (4) An analysis of the sizes of double, triple, and quadruple coronas gives no evidence that any were formed by ice crystals, and shows definitely that in all but a very small percentage of cases ice spicules could not have been the cause. Only in the case of the small, nearly colorless annuli almost invariably seen in conjunction with halos on the same cirro-stratus clouds, do ice crystal clouds appear to form coronas, except in rare instances.

The observation of a colored solar corona on a windowpane covered with small spicules, shows that the lack of positive evidence of colored coronas due to ice spicule clouds can not definitely exclude the possibility of their occurrence. Furthermore, a small, colored triple corona was once observed on a cloud apparently of tabular crystals.

Iridescence and coronas as guides to cloud temperature and, therefore, cloud height.—If, as seems established, coronas and iridescence indicate water clouds, and if, as appears reasonable, we assume that clouds of liquid droplets do not, except for very brief periods, occur at temperatures lower than the lowest at which liquid droplets have been observed, iridescent or corona-forming clouds may be correctly considered as having a temperature not lower than −35° C. Since the lower the temperature the more brilliant and extensive the iridescence and coronas, brilliance and angular extent of color may be used as a rough guide to the temperature, on the basis of observations made on fracto-cumulus clouds at computed temperatures. Once the temperature of the cloud is approximated the height may be estimated with the aid of the probable lapse rate in temperature at the time. Coronas and iridescence because of this relation to temperature should be observed as regularly as halos, and may be used as a criterion in distinguishing "alto-" from "cirro"-clouds.

INTRODUCTION

With dark glasses or a black mirror nephoscope at hand an observer may become acquainted with the beauties of the frequently occurring coronas and the less common iridescence near the sun or moon. Numerous observers have published descriptions of these beautiful phenomena and not a few have attempted explanations as well. The essentials of some of the published information and some details of a new series of observations will here be presented and discussed.

OBSERVATIONS OF CORONAS

Description of coronas.—Coronas are most readily seen about the moon, for here the light is not blinding. Near the moon there is a whitish area often with a ring of bluish tinge a short distance out, which grades into an orange-red ring still farther away. Often there is violet or purple and at times a further run of color through blue, green, yellow, orange, and red, with increasing distance from the moon. Still a third spectral series of rings is rarely seen. Around the brighter sun the more intense light occasionally gives as many as four spectral series. There appears to be no record of five series in complete rings having been seen at once, though five, six, or seven partial ones have been observed. The outermost series are usually mostly only diffuse greens and reds. Small, generally faint coronas are sometimes observed about a bright planet or star. Beautiful coronas are best seen on sheet clouds or thin fogs. Even with the passage of frayed clouds or wisps of fog, fleeting portions of coronas occur. Brilliant coronas can be observed in steam or breath fog or on a befogged or frosted windowpane.

* This paper was completed and first submitted on July 25, 1923. It has since been considerably shortened and slightly revised.—C. F. B.

Angular sizes of coronas.—On clouds the radius of the first red ring of a corona is most frequently about 1–5°. Occasionally it is less than ⅔° or more than 10°. The following table shows the frequency of coronas of different sizes in 132 measurements (mostly at Ben Nevis, Scotland) presented by Pernter,[1] and 164 noninstrumental observations of my own at Urbana, Ill., October, 1907–April, 1908, and at Worcester, Mass, November 1921,–June, 1923:

TABLE 1.—*Frequencies of angular sizes of coronas*

Radius of first red ring	0-1/2°	1/2-1°	1-2°	2-3°	3-4°	4-5°	5-6°	6-7°	7-8°	8-9°	9-10°	Total
From Pernter and Exner	0	5	43. 5	52. 5	21. 5	8. 5	1	0	0	0	0	132
Urbana, Ill	7	7	3	7	6	10	1	2	0	1	0	44
Worcester, Mass	10	9	10	20	23	25	14	5	2	1	3	122
Totals	17	21	56. 5	79. 5	50. 5	43. 5	16	7	2	2	3	298

The observations cited by Pernter were made with great care, and stated to the nearest minute of arc. Those made by Brooks were done roughly by estimation (Urbana) and by crude angular measurement to the nearest whole or half degree, with pencil or index finger at arm's length. The Worcester observations include seven instances of radii varying by 2, 3, 4, 5, or 6° within the same cloud. In each case these are put with the class showing the smallest of the observed radii, e. g., the observations of radii varying from 4–6° is classed with others of 4–5°.

TABLE 2.—*Occurrences of markedly noncircular coronas*

Radii	2-4°	3-8°	3-9°	{3-1/2 -10°}	4-6°	4-7°	4-9°	5-8°	9-13(?)°	Total
On lenticular clouds	1	1	1	1	2	1	1	1	1	10

Radii	3-7°	3-8°	4-9°	5-9°	6-9°	7-10°	7-12(?)°	
On fracto-cumulus clouds	1	1	1	1	1	1	1	7

The smallest corona measured at Worcester was 10′ to the first red ring, and the largest (only one observation) 13°. At distances of less than ½° from the edge of the luminary, except in the case of bright planets or stars, the ring becomes narrow and its coloring faint. Such very small coronas about the moon are called lunar annuli, and are almost invariably associated with halos in the same cloud. When the moon is not full, the corona, particularly when small, is not circular, but flattened on the side where the moon is flattened. The first condensation on a windowpane, e. g, when a cold wind springs up outside, may give a corona of 8° radius to the first red ring. One's breath fog in the open gives nearly the same, 7–9° to the first, and (once accompanying a 9° inner red ring) 16° to the second, red ring.

Anglar distances of second rings beyond the first.—In double coronas the second red ring usually occurs at a slightly less distance from the first red ring than that ring is from the edge of the luminary, as shown in table 3:

TABLE 3.—*Angular radius of second red ring in percentage of angular radius of the first*

Per cent	140-150	151-161	162-172	173-183	184-194	195-205	206-216	217-227	228-238	239-249	Over 250	Total
Kämtz	0	0	2	4	4	1	0	0	0	0	0	11
Ben Nevis (summer)	3	2	2	0	3	7	2	3	1	2	1	26
Ben Nevis (winter)	0	1	2	3	3. 5	7. 5	0	0	2	0	0	19
Brooks	1	1	5	15	1	4	1	1	1	1	5	36
All observations	4	4	11	22	11. 5	19. 5	3	4	4	3	6	92

[1] J. M. Pernter and F. M. Exner, Meteorologische Optik, 2nd ed., pp. 504–506, Wien and Leipzig, 1922.

The data here presented were compiled from observations collected by Kämtz and some made at Ben Nevis Observatory, and presented in Pernter's Meteorologische Optik,[2] and from observations made by Brooks at Urbana, Ill. (6 cases), Washington, D. C. (1 case), and Worcester, Mass. (29 cases). (First published herewith.)

Sizes of triple and quadruple coronas.—Pertner includes 10 instances in which third red rings were measured, and 2 in which there were fourth rings as well. Brooks' observations include 15 measurements of a third ring, 2 of a fourth ring and 1 of a portion of a fifth, as in Table 4:

TABLE 4.—*Angular measurements of red rings (in degrees and minutes from edge of sun or moon) for triple to quintuple coronas*

Red rings, cited by Pernter				Red rings, Brooks' observations				
First	Second	Third	Fourth	First	Second	Third	Fourth	Fifth
° ′	° ′	° ′	° ′	°	°	°	°	°
2 3	3 1	4 5		¼	1¾	3¼		
1 10	3 46	6 18	7 22	¾	2¼	4¼		
1 23	2 52	3 36		1¼	2¾	3¾		
1 43	2 35	4 24		4	6	9		
1 28	2 26	3 54		2.5–4	4–6	6–9		
2 23	4 30	7 39	9 25	5	9	11. 5	18	28
1 5	1 55	2 55		5	9	12		
1 22	2 5	4 23		¾	1½	3		
0 57	1 48	3 25		5–8	9–11	13–18	25–27	
	2 25	4 30		4–5	7–9	10–11		
				7	(9–)12	16		
				4–5	7–9	13a		
				3½	6	9		
				3–5–9	9–13	13		
				1	2–4	6		

The first three of Brooks' observations are from estimated diameters from which ½°, the diameter of the sun or moon, has been subtracted before dividing by 2 to get the radius. Among the others, where more than one angle is given for a single ring, the ring was of different radii in different directions.

Noncircular or irregular coronas.—Mention has been made above and Table 2 presented, showing that coronas markedly noncircular have been observed about one time in seven, on the average. Such coronas are most noticeable on clouds in which the different portions vary appreciably in age and, therefore, in size of particles. Sometimes when a smooth cloud with thickness gradually increasing toward the interior drifts in front of the moon or sun the corona is found to present the appearance of a parabola or hyperbola, open to the edge of the cloud and standing nearest the sun or moon where the cloud is densest. If the cloud is not smooth the corona is observed to have an irregular radius, as on wisps of fracto-cumulus clouds. The greatest departures from circular coronas, attaining at times 300 per cent of the distance of the nearest portion of the first red ring, occur with the most rapidly forming and evaporating clouds, for on the thin edges the droplets are so small that the red is diffracted to a large angle, while toward the interior, where the droplets have been growing for a short time, the diffraction is to an appreciably smaller angle (cf. Table 8, below). To observe a noncircular corona it is not necessary to wait till such a cloud is seen, for it can be viewed on a partially befogged or finely frosted window pane almost any cool evening. When such noncircular coronas are visible there is often much more or less irregular coloring out to considerable angular distances from the center of light.

OBSERVATIONS OF IRIDESCENCE

Perhaps the earliest full account of iridescent clouds, showing their relation to coronas and including a satis-

[2] Ibid.

factory explanation of the nature of the color, is that by Sir John F. W. Herschel, published in 1862.[3] Since Herschel's time, iridescence on clouds, usually associated with bright coronas, has been observed and described by many, but few have undertaken systematic observations. Hildebrandsson, Mohn, McConnel, Carlheim-Gyllenskiöld, Schips, and Arendt have provided the best series of observations.[4] Scattered observations are available in various meteorological books and journals and at times in general science journals.[5] These all deal with observations in sunlight. Moonlight is generally too weak to produce this effect. Brooks has seen more or less lenticular iridescent clouds in moonlight only twice and to a maximum of 12° from the moon. Three out of seventy-one observations of iridescent clouds at Upsala, 1866–1892, were in moonlight.[6] In sunlight iridescence may be brightly developed, usually showing bands of color hemming the edges of the clouds but having a tendency to be more or less concentric about the sun. Near the sun, coronas and this iridescence merge into one another in such a manner that it is evident they are of the same nature. Since iridescence usually occurs only on rapidly forming or evaporating clouds, it is usually seen with the change of wind on the approach of a storm or just after the wind shifts and the sky begins to clear as a storm passes on. The cold, boisterous winds on the rear of a cyclone are especially favorable to the development of iridescent fracto-cumulus and strato-cumulus clouds and higher, lenticular clouds.[7]

Some unusual displays of coronas and iridescence.—In 1922 and 1923, at Worcester, Mass., I observed four truly magnificent displays of solar coronas and accompanying iridescent clouds. In some respects these excelled even the wonderful occurrence described by Herschel. Brief summaries of these brilliant occurrences will, therefore, it is hoped, be worthwhile additions to data already published. Again and again I have seen one portion or another of such displays almost duplicated. The essentials of these four displays are: [8]

Those of November 29, 1922, and November 25, 1923, were noteworthy, because of the rapidity with which the clouds were forming and the colors changing, for the occurrence of five spectral series paralleling the edge of a cloud, in each case, and for the rapidity of the disintegration of the denser parts of the cloud into falling snow.

The iridescence of December 19, 1922, was notable for the extreme brilliance of the color over large areas, for the extent of visible colors through six or seven spectra out from the sun, and for the extent of the iridescence to 40° and 45° from the sun on clouds of two levels at the same time.

The display of February 25, 1923, was particularly interesting because of the successive presentation of beautiful coronas and iridescence on clouds at three levels; because of the well-marked triple corona with red rings at successive equal distances from the sun and with a weak sun pillar and lateral portion of a 22° solar halo or parhelion in the same (?) cloud at almost the same time; because of the marked difference in the radii of the corona on a lenticular cloud along the edge, vs. toward the center, and because of a similar diversity between the coronal radii in different parts of cumulus wisps.

Frequency of iridescence.—Most people being unequipped with dark glasses are not accustomed to looking up, and so never see these wonderful color effects. But he who will carry dark glasses can often view the unannounced color marvels of the sky. While the phenomenon in such brilliant form as here described for a number of instances is rare, nevertheless iridescence on clouds is a common, and, as McConnel agrees,[9] almost daily occurrence during some periods in winter.

Arendt in his bibliographic summary of observations of iridescent clouds [10] likewise shows that the phenomenon is of frequent occurrence, though the frequency of observation seems to depend largely on the observer. Thirty-six observations by Carlheim-Gyllenskiöld, 97 (including some of coronas only) by Schips (2 years), 42 by Mohn (22 years), 71 cited by Hildebrandsson (27 years) and 65 by Arendt (5 years) are discussed. Schips' observations showed 56 days with coronas or iridescent clouds in two years. From November, 1922, to October, 1923, I observed iridescence in 142 instances on 99 days. Iridescence was observed fourteen times on two or three well-defined levels of cloud simultaneously. Most of these, or 77 cases on 49 days, were during the cold, snowy months December to March, inclusive:

TABLE 5.—*Observations of iridescence by C. F. Brooks, November, 1922, to October, 1923*

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
Cases	10	14	13	33	16	10	3	9	10	12	4	8	142
Days	7	10	11	16	12	9	3	4	9	8	3	6	99

February was a particularly cold month, with light snowfall practically every day. Forest fire smoke in May and June, as well as the spending of less time in observing, limited the cases cited. While Schips' observations [11] show the four warmest (brightest) hours winter and summer to be those with the most frequent occurrence, I hesitate to classify my observations by hours, for the times I observed were usually between 8 and 9 a. m. and 1 and 3 p. m. I made no attempt to watch the sky at times other than when I happened to be outdoors, which was an average of about one hour per day. On the whole, I observed iridescence about two-thirds as often as coronas.

Angular extent of iridescence.—One feature not often mentioned in descriptions of iridescent clouds is the observation of these colors to angles exceeding 23°, the outermost limit reported by McConnel in his early article.[12] In my observations I have *usually* detected iridescence beyond 23°. In fact, it was not uncommon to see the pinkish or reddish hems of greenish clouds more than 40° from the sun and on several occasions to more than 50°:

TABLE 6.—*Angular extent of (solar) iridescence observed by C. F. Brooks*

Outer limit	5-10°	11-20°	21-30°	31-40°	41-50°	51-60°	Over 60°*	Total
Cases	†20-	27-	46	28	11	4	5	136

* Red tinge only.
† More consistent observations, with dark glasses, would probably make these figures far in excess of the others.

In some cases, especially in those showing the smaller angles, the actual limit of iridescence might have been greater had there been clouds in the right positions to show it. The extreme limit to which I am sure of both

[3] Sir John F. W. Herschel, Meteorology, London, 1862, 2nd ed., pp. 224–225.
[4] Th. Arendt, Irisirende Wolken, *Das Wetter*, Oct. and Nov., 1897, 14: 217–224, 244–252. A bibliographic summary of data available at that time.
[5] E. g. *Nature* (London), see "Iridescent clouds" in the indexes for vols. 31 (1885–86), esp. letter by C. Davison, in issue for Jan. 28, 1886, pp. 292–293, 2 figs., 33 (1886–87), esp. letter by T. W. Backhouse, in issue for Mar. 25, 1886, p. 486, describing iridescent clouds roughly triangulated at a height of 11–23 miles, 35 (1887–88), esp. J. C. McConnel, p. 533 and G. H. Stone, p. 581, the latter describing brilliant and extended iridescence at Colorado Springs, Colo., during chinook. An unusual display is described in *Science* (N. Y.), Mar. 10, 1922, N. S. 55:263.
[6] *Met. Zeitschr.*, 12:72, 1895.
[7] Cf. Arendt, loc. cit., pp. 247–248.
[8] The detailed descriptions have been placed on file in the libraries of the U. S. Weather Bureau, Washington, D. C., the British Meteorological Office, London, England, and the Prussian Meteorological Institute, Berlin, Germany.
[9] J. C. McConnel, on the causes of iridescence in clouds, *Phil. Mag.*, 5th ser., 1887, **24**, 423; 1890, **29**, 168–169.
[10] Arendt, loc. cit.
[11] Summarized by Arendt, ibid., pp. 246–247.
[12] Loc. cit., pp. 423–424.

red and green tints is over 57° (April 19, 1923), while for red alone it is 124° from the sun (January 26, 1924). I observed two colors out to 55° on July 26, 1920, at Washington, D. C.,[13] and on February 23, 1923, at Worcester, Mass. At least two other American observers have reported iridescence out to 45° or more from the sun. G. H. Stone's description of iridescent lenticular clouds observed at Colorado Springs, Colo., during a chinook, indicating great brilliance of color, and distribution from 5 to more than 45° from the sun, shows that his observation equalled in brilliance anything I have seen.[14] Mabel A. Chase recently reported a brilliant display of iridescent clouds in which the coloring extended to 45° from the sun,[15] while C. Bonacini has just published an account of fine iridescence, like a web of silk threads, of different colors, observed to 70° and more of angular distance from the man.[16]

McConnel, in the winter following the publication of his first article, observed iridescence on four occasions to more than 23°, the farthest being 37°.[17] He refers also to [18] unusually vivid iridescence seen in England and Scotland during the winters 1884–85 and 1885–86, described in a number of letters to *Nature*. Colors were visible on these at less than 50° and more than 130° from the sun (coronal and glory colors, respectively, each within 50° of the sun and a point directly opposite, i.e., 180° away). McConnel says these clouds seem to have been of a special type, and that one was found to be at least 11 miles high. It would probably be worth while on occasions of brilliant and extensive iridescence, about the sun, to examine clouds for iridescence at angles exceeding 130° from the sun.

Extent of iridescence on fracto-cumulus clouds at different temperatures.—Observations of diffraction colors on fracto-cumulus clouds at different temperatures are classified in the following table:

TABLE 7.—*Diffraction colors on fracto-cumulus clouds at different temperatures*

Extent of iridescence from sun	Number of cases	Computed cloud temperatures [1] (individual cases)	Computed cloud temperature		
		°C.	Average	Lowest	Highest
			°C.	°C.	°C.
10–20°	7	−7, −6, −4(h), −4(h), −2, 6, 14	[2]3	−7	14
20–30°	12	−13, −8(h), −7, −3, −2, 0(d), 2(h), 4, 6, 6, 7, 10.	0	−13	10
30–40°	13	−18, −18(h), −17(h), −16(dp), −14, −11(ph), −10, −8(d), −6, −6, −1, 3, 3(h).	−9	−18	3
Over 40°	7	−22(h), −20, −18(h), −18(s), −11(h), −10, −7(h).	−15	−22	−7
Total	39	(distributed by months as follows: Dec., 3; Jan., 3; Feb., 11; Mar., 5; Apr., 1; May, 1; June, 3; July, 1; Aug., 2; Sept., 4; Oct., 5.)			

[1] The cloud temperature was computed from the following approximate formula: $t_c = t_d - 0.2\,(t_a - t_d)/\,0.77$, in which t_c, t_d, and t_a are, respectively, the cloud base temperature, the dewpoint at the ground, and the air temperature at the ground, all in °C. For this formula the dewpoint was obtained with dew-point hygrometer in the case of observations marked (dp) with hair hygrometer (h), or with sling psychrometer (p or no letter). In one instance the cloud height was obtained by triangulation with the aid of the cloud shadow at known distance, and the temperature was then computed at an assumed lapse rate of 1.0° C. per 100 m.

[2] This average is not strictly comparable with the others, as observations at less than 20° were not attempted for July-October.

[13] C. F. Brooks, Iridescent Clouds, *Mo. Weather Rev.*, June, 1920, **48**: 333, ft. note.

[14] G. H. Stone, Iridescent clouds, *Nature*, Apr. 21, 1887, **35**:580.

[15] Mabel A. Chase, Iridescent clouds, *Science*, Mar. 30, 1922, N. S. **55**:263.

[16] C. Bonacini, Nubi iridate, *Boll. Bimensuale Soc. Met. Ital.*, 1924, **44**:73–74. The whole paper, pp. 71–78, extracts from a longer one, presents some other observations on iridescent clouds, mentions the scarcity of recorded observations of the sort in Italy, and attempts to place iridescence in a different category from coronas by offering to explain iridescence as the result of supposed fine striations on laminar crystals of which the author assumes iridescent clouds must be composed. (I am indebted to Miss E. C. H. Brooks for translating this paper.—C. F. B.)

[17] J. C. McConnel, On diffraction colors, with special reference to coronae and iridescent clouds, *Phil. Mag.*, 5th ser., **29**:168.

[18] Ibid., p. 170.

The data presented in this table appear reasonably accurate, notwithstanding three minor sources of error: (1) Observing the angular extent of iridescence, (2) determining the dew point, and (3) obtaining the cloud temperature. The angular observations of iridescence depend not only on distinguishing the colors, but also on clouds being at distances such that the limit may be established. In the case of fracto-cumulus clouds, the number of units and their motion allows fairly readily the determination of the angular limits of iridescence, probably correct to within 5°. Determining the dew point in cold weather is always difficult. During the months December, 1922, to October, 1923, when these observations were made, I took almost daily observations with the sling psychrometer, and in the cold weather of December and January supplemented these with determinations of the dew point with a table-salt and snow mixture in a silver or bright aluminum cup. Throughout the period a hair hygrograph was in operation. The dew-point observations made with the dew-point hygrometer and the psychrometer at wet-bulb temperatures above 0° C. may be considered accurate within 0.5° C., those with the psychrometer below 0° C., within 1° C., and those obtained from the hair hygrograph, correct within 1.5° C. The temperature at which air ascending from the ground would reach saturation has been taken as the probable cloud temperature. This assumption is open to errors which are known to be generally small. Clayton [19] has compared observed heights of cumulus clouds with those computed by the dewpoint formula and found the computed heights lower (−) or higher (+) by the following number of meters in 10 instances: +55, −42, −12, +104, +42, −4, +35, −14, −133, and −5. The average difference is ±45 m., which under adiabatic conditions, corresponds to an average error of 0.5° C. Thus, it seems safe to assume that the cloud temperatures indicated are probably correct to within 1° C. in 17 instances, to within 1.5° C. in 10 more, and to within 2° C. in 11 more. The remaining case, in which the cloud height was obtained, with the aid of its shadow, by rough triangulation, is probably not more than 1° C. in error. As the most extended iridescence is unusually observed on forming cumulus wisps, the temperatures of the cloud bases reasonably approximate those of the clouds on which the iridescence is observed.

Accepting Table 7 as it stands, it is noteworthy that both the average and extreme temperatures are lowest for the most extended iridescences and highest for the least extended, and that there is an orderly gradation between. Owing to the large range of cloud temperature, 15 to 23° C., within each group it is evident that further observations are required before any averages can be dependable within a degree or two.

A closer relationship between extent of iridescence and computed cloud temperature seems to be prevented by the varying intensity of convection. The more rapidly the clouds are forming, that is, the more intense the convection, the greater are the cloud areas with droplets sufficiently alike in size to make the colors stand out plainly. Therefore, the more intense the convection, cloud temperatures being equal, the more extended the iridescence is likely to be. Nevertheless, this factor is not sufficient to obscure well marked changes in the extent of iridescence accompanying appreciable changes of cloud temperature on any day. Four instances may be cited of the usual increase in the angular extent of

[19] H. H. Clayton, World Weather, Table XI, p. 162, New York, 1923.

iridescence with falling cloud temperature from morning to afternoon: December 13, 1922, February 10, 18, and June 27, 1923. The observations on December 13 showed a greater brilliance of iridescence in the afternoon than in the morning, the computed cloud temperature having fallen from −14° to −18° C. The observations on February 10 showed an extent of iridescence increasing from 15° at 1:05 p. m., when the cloud temperature was probably −4° C., to 22° at 1:30 p. m., when the cloud temperature had fallen to −7° C. On February 18, while there seems to have been no change in cloud temperature, which was probably −18° C. at 9 a. m. and 11:40 a. m., the iridescence spread from 30° at the earlier hour, to 40° with reddish tints visible to 50° out, at the later observation. Here the spread was apparently owing to increased intensity of convection. On June 27 the iridescence extended to 20° at 6:30 a. m., but to 30° at 1:20 p. m. The computed cloud tempertures fell from 14° to 10° C. in this period. At both observations there was considerable turbulence in the 25 mi./hr. west wind. On August 22 the iridescence increased from 25° to 28° out from the sun from 12 to 4 p. m., during a dry, colder and colder gale. September 30, 1923, there was an instance of decreasing radius of iridescence with rising cloud temperature as a hurricane drew near. About 11:30 to 12, angular limits of 32, 35, 35, 38, and 38° were observed, the computed cloud temperature being about 3° C., while at 2 p. m. 25° was the limit, the computed cloud temperature being 4° C. Though some of the observations do not fall well into line, it appears that a change of about 3° C. in cloud temperature is sufficient to change the extent of iridescence by 10°.

At low temperatures cumulus clouds are ephemeral, quickly transforming into clouds of falling snow. At temperatures much below −20° C. the change is so rapid that iridescence is too fleeting to be extensively observable at one time, unless new clouds are continually forming in large numbers. At temperatures above 5° C. condensation of the more abundant supply of water vapor so quickly results in numbers of droplets larger than the very small size (about 0.005 mm. diameter) which best form extensive iridescences, that these colorings are rarely to be seen more than 20° from the sun. Obviously, at temperatures between about −20° C. and 5° C. the clouds are neither too ephemeral nor composed of droplets too large to provide extensive iridescence.

Summary.—The observations presented show that coronas are more or less concentric rings of color in spectral successions at moderate angular distances from the sun. Iridescence, however, is a bright to faint coloring from any part of the spectrum, in irregular splotches or in bands paralleling the edge of a cloud. With movement toward or from the sun the colors of particular cloudlets change as they move through the more or less fixed zones of potential color for the sizes of the cloud particles. On near approach of an iridescent cloud to the sun the colors take on a more or less circular arrangement, with a red ring at a certain minimum radius. Iridescent coloring has been noted on several occasions by different observers to an angular distance of 45° from the sun. The brilliance, however, usually fades rapidly beyond a distance of 20° or 30°.

Windowpane iridescence.—Color bands suggestive of those on the edges of clouds may be seen on windowpanes covered with frozen fine dew. These, however, are separated from the corona by a colorless zone, and the arrangement of colors is the reverse of that in the corona. Unlike iridescence on clouds, such bands are, evidently, produced by the interference of transmitted light with that transmitted and doubly reflected from the opposite faces of the thin plates of ice, held in parallel orientation on the windowpane. One cold morning when there was frozen dew and a new deposit of frost on different parts of the same windowpane, solar coronas could be seen on both, but the noncircular color bands on the deposit of frozen dew only.[20]

CAUSE OF CORONAS AND IRIDESCENCE

The explanation [21] for these beautiful colors on clouds, is that they are owing to interference in diffraction of light. So far as clouds are concerned, coronas and iridescence are probably due only to diffraction by very small particles. In passing through the spaces between the particles the light waves spread as from new sources, with convex wave fronts. The waves from the different spaces cross, and, in consequence, make alternating zones of double illumination and darkness. Each wave length has its own sets of wave fronts, which on interfering produce bright and dark bands at different angular distances from the source of light. Thus the bright phase of one color occurs in the dark phase of another, and this leads to rings of colored light at certain angles from the luminary. As the wave fronts of the light of shorter wave lengths, e. g., blue, are least diffracted in passing through a dusty or cloudy medium, the color seen nearest the sun or moon is bluish, and is followed in succession by green, yellow, orange, and red. Then there is another series marking the second zones of reinforcement of the several colors—violet, indigo, blue, green, yellow, orange, and red. The size of the innermost red ring, and, of course, of all the others, too, is dependent on the size of the particles causing the diffraction. The smaller the ring the larger are the particles making it. This relation between the radius of the first red ring and the diameter of the diffracting spheres is given by the following formula:[22]

$$\text{Sin } r = .00082/d,$$

in which r is the angular distance of the first red ring from the edge of the luminary, 0.00082 a constant for the first red ring (n [=1]+0.22) 0.000671 [the wave length of red, in mm.], and d the diameter of the droplets (in mm.) responsible for the red ring of radius r. The following table is derived from this formula:

TABLE 8.—*Relation of radius of first red ring of corona (r) to diameter of droplets (d)*

r	0°10′	0°20′	0°30′	1°	1°30′	2°	3°	4°	5°	6°	°8	10°	12°
d (in mm.)	0. 282	0. 141	0. 094	0. 047	0. 031	0. 023	0. 016	0. 012	0. 009	0. 008	0. 006	0. 005	0. 004

From the radius of the chestnut-brown corona Richardson has just shown [23] that

$$\text{(diameter of obstacle)} = \frac{5.3\times10^{-5}\text{ cm.}}{\left\{\begin{array}{c}\text{(radius of chestnut-brown}\\ \text{corona) minus}\\ \tfrac{1}{2}\text{ (radius of source).}\end{array}\right\}}$$

[20] For details concerning interference of light see books on physics, or the Encyclopedia Britannica, 11th ed., vol. 14, pp. 685–693 (Interference of light), and vol. 8, pp. 238–255 (Diffraction of light).

[21] For details on diffraction by water droplets see W. J. Humphreys, Physics of the Air, Philadelphia, 1920, pp. 528–536, and on diffraction by ice spicules see J. C. McConnel, On diffraction colors, with special reference to coronae and iridescent clouds, *Phil. Mag.*, 28: 272–289, 1889, 29: 167–173, 1890.

[22] Derived from that presented in Humphreys, op. cit., p. 534.

[23] L. F. Richardson, The brown corona and the diameter of particles, *Quar. Jour. Roy. Met'l. Soc.*, Jan., 1925, 51: 1–6.

From this formula, applicable for droplet diameters of ordinary size, 5 to 20 microns, Table 8 b has been computed.

TABLE 8 b.—*Relation of radius of chestnut-brown ring (r) to diameter of droplets (d)*

r	1° 40′	2°	3°	4°	5°	6°
d (in mm.)	0.020	0.016	0.010	0.008	0.006	0.005

Iridescence on clouds, as already described, seems to be merely a mixture of coronas of different radii resulting from the particles being of different sizes in different portions of the cloud at the same angular distance from the sun or moon.

History and criticism of theories as to the cause of coronas and irridescence.—So far as is known, the formation of coronas and irridescent colors on clouds, as just explained, can take place only as the result of interference of light of different wave lengths as it is diffracted in passing minute particles. Snow crystals are unequal in their several dimensions, and oriented more or less fortuitously. Thus, even when the crystals are sufficiently small to make a corona large enough to be seen, their irregularity of form and orientation should so diffuse the diffraction pattern as to render it practically, if not quite, invisible. When interference colors are seen on clouds, it is presumed, therefore, as must usually be the case, that the particles involved are liquid droplets. The occurrence of such clouds in the air at temperatures far below the usual freezing point of water presents no difficulty, for clouds or fogs of liquid droplets have been observed at temperatures down to −34.5° C., as will be noted below. Why liquid droplets form and do not freeze at such low temperatures is not known.

The similarity of iridescence on clouds to iridescent films led Stoney[24] to suggest that this coloration was caused by interference of light reflected from the opposite faces of thin, transparent plates of ice. McConnel[25] with numerous personal observations[26] at his command, immediately pointed out objections fatal to Stoney's hypothesis. His own generally excellent discussion (1887) was marred, however, by the unnecessary assumption that all high, and therefore cold, clouds must be of ice and, consequently, that most of the iridescence he had seen on clouds had to be explained as the result of the diffractive effect of ice spicules.[27] Nevertheless, his detailed mathematical discussion of coronas includes both spicular and water-droplet kinds. Pernter[28] accepted McConnel's theory, and assumed that all the larger and brighter coronas must be caused by ice spicules, for at the large angles to which iridescence was observed the intensity of light diffracted by water droplets would not be nearly so great as that from ice spicules. Simpson[29] questioned several of Pernter's explanations and brought a new point of view to bear on the subject.

Simpson's conclusions were based on observations with the Scott expedition in the Antarctic. On September 24, 1911, he observed a 38° fogbow and its double, at temperatures between −15° and −21° F. (−26.1° and −29.4° C.):

> The observation proves that the fog was composed of water drops having a radius smaller than 0.025 mm., and this with a temperature of −21° F. (−29° C.). Support is lent to this conclusion by the observation that the hair of sweaters and fur bags became covered with hoarfrost, which is a sure sign of supercooled water.

The occurrence of water droplets at such low temperatures was also noted by J. P. Koch in the far interior of Greenland:[30]

> Today [June 10] we saw * * * the white rainbow [fogbow] at a temperature of −31° [C,]. The rainbow occurs always in water clouds, never in ice clouds, so we knew, therefore, that we here had to do with water at −31°. It is naturally possible that the fog cloud had a higher temperature than the air on the ground, though at any rate it could not have been over −18° [the highest recent temperature] * * *. [June 11, longitude 42° 53′ W.] We have again seen to-day the white rainbow, this time at −33.4°. This record for undercooled water will be hard to break.
>
> 12 June, 2 a. m., camp site, 42° 53′. Again the white rainbow is there, this time at −34.5°. The record has been broken earlier than I expected. (Trans. by C. F. B.)

While Simpson's and Koch's observations give us temperatures for liquid droplets lower than any previously observed, clouds of liquid droplets as low as −20° to −22° C. (−4 to −8° F.) had been observed in 1893 by A. Berson in a balloon.[31]

On Ben Nevis, fogbows, indicative of liquid droplets, "have been observed at all temperatures."[32] Water has been supercooled to −80° C.[33]

Simpson says:

> It is now generally admitted that while halos are caused by the refraction and reflection of ice crystals, coronæ are due to diffraction effects of either small drops of water or thin ice needles. From certain observations made in the Anarctic I was led to doubt the possibility of ice crystals ever forming diffraction effects * * *.
>
> Pernter's reasons for believing that coronæ are produced by ice crystals may be summed up in the three following statements:
>
> (*a*) Coronæ are seen on clouds having temperatures much below the freezing point.
>
> (*b*) The most beautiful coronæ appear on light white cirro-cumulus or fine cirro-stratus clouds; and these clouds are always composed of ice crystals.
>
> (*c*) Halos and coronæ have been observed at the same time; and as halos are a sure sign of ice crystals the coronæ must, therefore, be formed in ice clouds.

Simpson made the following points: (1) It was not necessary to suppose that very cold clouds must be of ice spicules, for he had observed a fog of liquid droplets at a temperature of −15 to −21° F. (2) Halos and coronas, he claimed, were not to be seen in the same cloud at the same time, notwithstanding entries of both at the same observation. (3) The tendency of spicules to fall with their long axes horizontal should make any coronas formed by them brighter above and below the sun or moon than on the sides. (4) The diverse arrangement of spicules should so weaken their diffracted light as to make the coronas caused by them so faint as not to be noticeable. (5) An explanation of iridescence as a phenomenon not always caused in the same manner as coronas is unnecessary.

Humphreys[34] accepts Simpson's treatment with due caution, and does not touch on Pernter's elaborate discussion. Fujiwhara and Nakano,[35] however, review McConnel's, Pernter's, and Simpson's explanations and concludes that while the Japanese studies are not fatal to the ice-cloud theory, "the water-cloud theory of Doctor Simpson is correct so far as supercooling can take place.

[24] G. Johnstone Stoney, On the cause of iridescence in clouds, *Phil. Mag.*, 5th ser., 24: 87–92, 1887. Repr. from *Sci. Trans. Roy. Soc., Dublin*, 2nd ser., 3:637 fig, 1887 (fig. 9).
[25] Loc. cit., pp. 422–434.
[26] Some presented and discussed in *Nature*, Apr. 7, 1887, 35:533, before his extended discussion in *Phil. Mag.*, loc. cit., 1887, 1889, 1890.
[27] McConnel, loc. cit., 1887, p. 424.
[28] J. M. Pernter, Meteorologische Optik, vol. 3, pp. 449–456. Wien & Leipzig, 1906.
[29] G. C. Simpson, Coronae and iridescent clouds, *Quar. Jour., Roy. Met'l. Soc.*, Oct., 1912, 38:291–301, 3 figs.
[30] J. P. Koch, Durch die weisse Wüste. Die dänische Forschungsreise quer durch Nordgrönland, 1912–13. (A. Wegener, translator.) Ref. to pp. 207–209.
[31] R. Süring, Wissenschaftliche Luftfahrten, vol. 2, p. 192, Braunschweig, 1900.
[32] McConnel, op. cit., 1890, p. 168.
[33] E. W. Washburn, An introduction to the principles of physical chemistry, etc., New York, 1915, p. 77.
[34] Op. cit., pp. 534–536.
[35] S. Fujiwhara and H. Nakano, Notes on iridescent clouds, *Jour. of the Meteorological Soc. of Japan*, June, 1920, 39th yr., pp. 1–9, 3 figs.

The theory [Simpson's] is proved by means of numerical calculation of some typical cases from actual observations and by a simple experiment. [The] hemming or crossing nature of iridescent color on clouds, and its preponderating appearance on thin clouds such as Ci.-Cu., A.-Cu., or Fr.-Cu. are explained." Exner has recently answered Simpson's criticisms of some of Pernter's and McConnel's explanations.[36]

Exner replies as follows to all but (5): (1) Even though liquid droplets may exist at low temperatures, there are clouds of ice spicules nevertheless. (2) Observations in Holland in 1918 reported by Van Everdingen[37] include 10 cases of simultaneous halo and corona on the same cloud. "It is therefore apparently certain that coronas also form in ice clouds." (Trans. by C. F. B.) (3) Since halos, which are formed only by ice crystals, occur with equal brightness in all directions from the sun, it is reasonable to suppose that ice-crystal coronas can do so, too. (4) Computations do not sustain Simpson's assumption that the colors would be too weak to be noticeable in diffraction by spicules. Here the matter stands.

Do angular measurements of coronas show ice spicule origin?—Among the 132 careful angular measurements of coronas collected by Kämtz or made at Ben Nevis Obervatory[38] are the dimensions of 56 double, triple, or quadruple coronas. Now Pernter shows mathematically[39] that with nonspicular coronas the second maximum of light outside the central source comes at a distance of only 506/610ths, or about 78 per cent, as far beyond the first maximum as the first maximum is from the luminary, while with spicular diffraction the successive maxima are at equal angular distances outward from the source of light. Unfortunately, this does not necessarily allow the identification of ice-spicule coronas, on the basis of the occurrence of angular radii of second red rings at just double those of the first, for the clouds are not of droplets all the same size within the range of the corona. This is true even if we leave out of consideration the well-known occurrence of horizontal differences which are the cause of irregular and noncircular coronas and of iridescence. Assmann, making measurements on the Brocken,[40] in a quiet cloud layer near the summit, found that the droplets ranged from 0.005 mm. in diameter at the very top of the cloud layer, through 0.008 mm. 10 meters below the top, 0.011 mm. at 30 m. below the top, to 0.013 mm. at the base (80 m. below the top). Braak found a similar range of sizes in clouds.[41]

Assuming that the effect of the upper half of the cloud would be as if the diffraction were by particles 0.009 mm. in diameter, and that of the lower half of the cloud by particles 0.012 mm. in diameter, the following would, in this case, be the sizes of the successive red rings produced:

	°	°	°	°	°
By droplets 0.012 mm. in diameter	4	7	10	13	16
By droplets 0.009 mm. in diameter	5¼		9⅛	13	17
The result would be red rings at	4⅝	[Extinction]	9½	13	Near 17

On account of the greens of the smaller drops falling at the same distance as the reds of the larger ones, these colors would, in this instance, not appear brightly between about 5½ and 8½° from the luminary. It is evident that the corona such as might have been observed on this cloud would have had its second red wing at 202 per cent of the distance of the first, almost exactly the theoretical 200 per cent for ice spicule coronæ instead of the theoretical 178 per cent for a cloud of droplets all the same size, and that the third and fourth rings would have been at successive distances smaller than that between the first and second. If there were a greater diversity in the sizes of the droplets the first maxima of color would generally fall in opposite phase and thus extinguish the color, or leave but a faint diffuse corona, perhaps without a second ring. If the sizes were more nearly alike, say, making first red rings at 4° and 4⅔°, the seconds would be at 7° and 8⅓°, making a good first ring at 4⅓° and a diffuse second one at 7⅔°, or 177 per cent of the distance of the first, practically the theoretical 178 per cent. There would be no third ring.

This rough analysis may explain the peculiarities to be noted in the angular measurements presented in Tables 3 and 4. As it is normal for cloud droplets to differ in size within the same cloud, it is normal for the second ring of double coronas to be between 178 per cent and perhaps 205 per cent of the distance of the first from the sun or moon. As a considerable diversity in sizes will prevent the formation of coronas, it is not surprising that angular distances of second rings larger than 205 per cent of those of the first are not often observed. Furthermore, in the cases of triple and quadruple coronas it is easy to see why there should be a considerable diversity in the angular distances between the successive red rings; extinctions and reinforcements blot out rings where they might be expected and intensify others farther out, a third and a fourth ring, e. g., representing the third and fourth maxima for the smaller droplets and the fourth and fifth for the larger, the second maximum for the larger droplets having been extinguished, as in the example cited. In these measurements there is obviously no assurance that any corona was formed by spicules.

Ice clouds and simultaneous occurrence of halos and coronas.—Even if these observations can not indicate ice-crystal origin of colored coronas, the almost invariably simultaneous occurrence of lunar annuli and halos constitutes practically indisputable proof of the ice-crystal origin of at least this type of corona. Seventeen times in 27 months I have recorded observations of lunar annuli on cirro-stratus clouds. In 14 of these there was a lunar halo at the same time, apparently on the same cirro-stratus cloud in each case. On one of the remaining three there appeared to be a faint halo; on a second, a halo was observed half an hour later; and on the third no halo was noted, probably because the sky was too heavily clouded to make it visible, though possibly because the thunderstorm cirrus in which it formed did not make a halo. Another corona was visible at the same time on lower clouds, and a thunderstorm within hearing distance occupied the northern sky from northwest to northeast. Thus it seems that annuli are rarely observed except on cirro-stratus clouds which have halos, and, therefore, on clouds unquestionably formed of ice crystals. Although it is possible that such a corona may be caused by liquid droplets from the melting of the lower portion of the sheet of falling snow which constitutes cirro-stratus,[42] ice

[36] J. M. Pernter and F. M. Exner, Meteorologische Optik, pp. 488–495, 2d ed. partly reworked by F. M. Exner, Wien and Leipzig, 1922.
[37] Ibid., p. 462.
[38] Cited by Pernter, loc. cit., 1906, pp. 466–468. Also in 2d ed., pp. 504–506.
[39] Ibid., 1st ed., p. 454, figs. 165, 165a; 2d ed., p. 483, figs. 182, 183.
[40] R. Assmann, Microscopische Beobachtung der Wolken-Elemente auf dem Brocken, *Met. Zeitschr.*, Feb., 1885, 2:43–45.
[41] C. Braak, On cloud formation, K. Mag. en Met. Obs. te Batavia, Verh. 10, 1922, pp. 18–27.

[42] C. F. Brooks, in *Mo. Weather Rev.*, June, 1920, 48:333, and *The Met'l Mag.*, May, 1921, 56:95. Also C. K. M. Douglas, *The Met'l Mag.*, Jan., 1921, 55:274, and June, 1921, 56:126–127.

crystals of a size small enough to make droplets of corona-producing size would themselves make a corona, though of smaller radius. Another possibility, the simultaneous occurrence of droplets and crystals at the same level,[43] though this would produce a corona, is very unlikely to be the cause of such enduring annuli, for, owing to the lower vapor pressures of ice, water droplets are too unstable in the presence of ice to last long.

Ice coronas on windowpanes.—Whenever windowpanes are covered with a deposit of small drops of dew or with ice plates (frozen dew), flat crystals, or ice spicules, coronas may be seen about the moon, sun, or other light shining through. Such coronas, in the cases of panes covered with ice crystals are, apparently, invariably small and never double, and their colors, while bright, not so pure as those of water-droplet coronas. Except for their colors, owing, presumably, to a homogeneity greater than that found in a cirro-stratus cloud, and to parallel orientations in the same place, these coronas correspond to annuli seen on cirro-stratus clouds.

Direct observation of frosted windowpanes thus upholds the reasonable surmises from annuli seen on cirro-stratus clouds, that ice-crystal clouds can produce small essentially colorless coronas.

Water droplets as the cause of nearly all if not all colored coronas.—The evidence in favor of water droplets being the cause of nearly all, if not of all, colored coronas, and especially of the brilliant coronas and associated iridescence, appears much stronger than that which can be presented for ice-spicule or other ice-crystal origins. Observation of diffraction colors produced by fogs or clouds known by direct observation to be of water droplets indicates that clouds of water droplets do produce brilliant and extensive coronas and iridescence. Fujiwhara and Nakano[44] experimenting with steam fog reported that colors were visible to 45° from the source of light. Lcomotive exhaust fog on a cold sunny day sometimes gives a flash of color immediately before disappearing. On March 8, 1923, I saw this occur at about 40° from the sun. The same effect may be obtained in cool damp weather or in cold weather, when breath fog readily forms, by blowing in the direction of a light, and, better still, by blowing onto a cold windowpane from a distance of a foot or two. Experiences of mountain observers, balloonists, and aviators with glories on clouds of liquid droplets are commonly described, but never (?) a colored corona or glory on a cloud known to be wholly of ice.

Iridescence on clouds of water droplets only.—In view of the marked differences in sizes of cloud particles required in different portions of a cloud in order to produce iridescence, it is likely that only clouds of quickly condensing or evaporating water droplets could have sufficient local homogeneity yet sufficient general heterogeneity to be iridescent. While some coronas may be spicular in origin and others due to hexagonal ice crystals, iridescence probably occurs only on clouds composed at least partly of water droplets. Certainly the most brilliant phases of iridescence are produced only by water clouds. Iridescent clouds are frequently seen to yield a fall of noniridescent snow, which is quite distinct from the mother cloud. Under such conditions the corona and iridescence usually do not last long enough for a sheet of crystals to develop sufficiently to produce a halo, if, indeed, the crystals usually are of a halo making kind. However this may be, I have on three occasions observed iridescence and on eight others a corona without iridescence, simultaneously with halo or parhelion, evidently on a cloud made up largely of liquid droplets and a sheet of snow falling from it. In a number of other instances of simultaneous halo and corona the cirro-stratus cloud of crystals responsible for the halo seems to have been above the clouds causing the corona. This occurrence of cirrus clouds so commonly attached to or growing from iridescent clouds led earlier observers to conclude erroneously that in spite of the rapidity of formation and evaporation, which pointed to water droplets, the iridescent clouds must nevertheless be of ice crystals.

Conclusion on cause of coronas and iridescence.—Since, therefore, (1) iridescence to the greatest limits observed occurs on clouds known or presumed, with greatest confidence, to be of water droplets, (2) liquid clouds occur at low temperatures, (3) angular measurements seem to indicate that coronas occur generally if not quite exclusively on water-droplet clouds, and (4) there appears to be no instance of a colored corona on a cloud known or reasonably presumed to be wholly of ice crystals, it seems justifiable almost without reservation to uphold Simpson in contending that coronas and iridescence occur exclusively on clouds of liquid droplets.[45] All doubt on this score can probably be removed only through careful direct observations from airplanes or airships driven into clouds showing coronas, glories, or iridescence, though a laborious computation or diffraction experiments with suitable artificial spicules would be helpful.

The consequences of this conclusion, pending direct observations to establish or overthrow it, are interesting when considered in conjunction with the relations between temperature and extent of iridescence on fracto-cumulus clouds.

IRIDESCENCE AND CORONAS AS GUIDES TO TEMPERATURE AND, THEREFORE, GENERAL CLOUD HEIGHT

The angular distance to which iridescence may be seen is not only a function of the size of the droplets involved but also one of the brightness of the light and the degree to which white light can be shut out, as with dark glasses. Since the moon, which is one-millionth or less as bright as the sun, can produce visible iridescent colors to a third maximum 11° out, or a second one at 12° from the lighted edge, iridescent colors, per se, are probably strong enough about the sun to be visible to the theoretical limit of 90° if reflected light and sky light were not so strong. Homogeneity in the density of a cloud, usually shown by its apparent smoothness, and homogeneity in the size of droplets over appreciable areas, is essential to the development of the widest angles of visible iridescence. Still another factor is the contrast in the size of droplets between interior and edge of the cloud. This must be sufficient to yield different diffraction colors at the same angular distances from the sun. Furthermore, the cloud must be of sufficient density to make bright diffraction colors. A very thin cloud at a large angular distance diffracts too little of the colored light even to be seen. A thick cloud, however, is not likely to let enough light through to give coloring, or else it reflects so much light that the coloring is obscured.

The temperature at which condensation takes place has an important bearing on the sizes of the droplets and the density of the cloud produced, and therefore, on the

[43] A phenomenon once observed by Douglas, ibid., p. 274.
[44] Loc cit., p. 8.
[45] G. C. Simpson, loc. cit.

extent and brilliance of diffraction colors in the cloud. The lower the temperature the less is the vapor that can be condensed, and, assuming an equal number of nuclei at different temperatures, the smaller are the droplets that can be formed. Thus the cloud formed at low temperature is likely to be of smaller droplets and less dense than one formed at high temperature. Since the extremely small droplets are of little consequence when other sizes predominate, the smaller the size of the majority of droplets the more uniform are the sizes within a cloud, and, therefore, the purer are the colors produced. A cold cloud, thus, is much more favorable to widespread diffraction colors than a warm one. Pernter's conclusion, from observation of more beautiful coronas when the temperature was low, that the clouds causing them were "surely ice clouds" does not seem tenable.[46]

With moderate-sized particles, such as give the first red ring at 3° from the sun, iridescence from the particles of this size would not be expected in brilliant form beyond 11°, the limit of the fourth red ring, while with small particles, such as make the first red ring at 6° from the sun, bright iridescence should occur to 21°. With exceedingly small particles, such as occur in wisps of fracto-cumulus on cold winter days, on which the first red band occurs 10° or perhaps even 12° from the sun, fairly bright diffraction colors are visible to 35° or 40°, the position of the fourth red ring. But portions of the fifth, sixth, and perhaps even the seventh rings are sometimes bright enough to be visible. This extends the visible iridescence to more than half again as great a distance as the bright iridescence. To the extent, therefore, that temperature controls the size of the cloud particles, the angular distance to which diffraction colors are visible may be used as a rough index to the temperature of the cloud, and, through temperature to the height of the cloud.[47]

Iridescence as an indicator of cloud temperatures and altitudes thus becomes *a factor of value in cloud nomenclature*. An examination of Table 9 indicates at once the possibility of generally distinguishing thin alto-stratus and alto-cumulus clouds from cirro-stratus and cirro-cumulus, on the basis of the occurrence of iridescence. If we may judge from the temperatures of iridescent fracto-cumulus clouds (see Table 7), it is only with iridescences extending to 40° or more except on very rapidly forming clouds, that the observer is likely to be viewing clouds having temperatures appropriate to the average heights of cirro-cumulus and cirro-stratus.

[46] Loc. cit., 1st ed., p. 449.

[47] The heights of iridescent clouds was discussed at length a few decades ago. H. Mohn, in an article, Irisirende Wolken (*Met. Zeitschr.*, 1893, 10: 81–97, 240) sought to prove from the late disappearance of sunset light (?) on clouds that were iridescent before sunset that iridescent clouds were at great heights, up to 140 km. O. Jesse, however, said (ibid., pp. 384–385) he had seen iridescent clouds usually at moderate elevations, up to about 7,000 m., and suggested that the late darkening of the clouds observed by Mohn did not represent the actual setting of the sun at their height, but merely the end of more or less intense indirect lighting there. Mohn replied (ibid., p. 460) that the suddenness with which the light left the clouds precluded any lighting less direct than sunlight. Reimann (ibid., 1894, 11: 200) sustained Jesse in saying that his observations showed iridescent clouds to be at no great height. Hildebrandsson, however (ibid., 1895, 12: 71–72), cited another observation of late darkening of a previously iridescent cloud, which under the assumption of direct sunlight indicated a height of 132 km., conforming to Mohn's computations. K. Schips cited (ibid., p. 312) an observation of a very beautiful iridescent cloud that could not have been very high. C. Kassner in summarizing the discussion (ibid., pp. 379–382) suggested that there were two sorts of iridescent clouds, those at moderate heights, and those at very great heights.

If the clouds observed by Mohn and Hildebrandsson had been lighted by the sun directly up to the time when they darkened, then they should have continued to be iridescent till that time, instead of losing their iridescence at about the time of general sunset. It does not take much light to make a cloud look bright in a dark sky, and it is reasonable to suppose that even indirect light might be cut off rather suddenly when the sun ceased to shine on the distant cloud, or whatever it might be that sent the indirect light. There seems no reason for believing that iridescent clouds exist to phenomenal heights.

TABLE 9.—*Average heights of intermediate and upper clouds and the average temperatures at those heights, summer and winter, in the eastern United States and western Europe.*

	United States (Washington, D. C., and Blue Hill, Mass.)				Europe (Trappes, France, and Potsdam, Germany)			
	Summer		Winter		Summer		Winter	
	Average height	Average temperature at average height	Average height	Average temperature at average height	Average height	Average temperature at average height	Average height	Average temperature at average height
	Km.	*°C.*	*Km.*	*°C.*	*Km.*	*°C.*	*Km.*	*°C.*
Ci. St.	W., 10.6	−43	9.5	−49	T., 7.9	−30	5.9	−28
	B. H., 10.1	−40	8.9	−46	P., 8.1	−31	7.6	−41
Ci. Cu.	W., 8.8	−32	7.4	−37	T., 5.8	−15	5.6	−27
	[1] B. H., 8.4	−29	[1] 6.4	−30	P., 5.9	−16	5.4	−25
	B. H., 6.7	−17	6.2	−29				
A. St.	W., 5.8	−11	4.8	−19	T., 3.8	−3	3.8	−15
	B. H., 6.3	−14	4.6	−18	P., 3.3	0	3.0	−9
A. Cu.	W., 5.0	−5	3.8	−13	T., 3.7	−2	4.3	−18
	B. H., 3.8	+2	3.7	−12	P., 3.6	−2	3.4	−12

[1] Heights from H. H. Clayton, Discussion of the cloud observations, etc., Ann. Astr. Obs. Harvard College, vol. 30, pt. 1, p. 340, 1896.
These cloud heights are from the table in W. J. Humphreys', Physics of the air, Philadelphia, 1920, p. 306, copied from J. v. Hann's, Lehrb. d. Meteorologie.
Temperatures for western and central Europe were read from Humphreys, loc. cit. Figure 16, and for the eastern United States, from Gregg, loc. cit., Figure 13.

Herein lies a justification for recommending the use of diffraction colors for distinguishing alto-cumulus from cirro-cumulus and alto-stratus from cirro-stratus. The value of corona observations for this purpose has long been recognized,[48] but they seem to have been applied in observational practice only in Austria-Hungary and Russia,[49] and very recently in the United States.[50] Brooks recommendations of three years ago [51] require minor modifications, in the light of the study of coronas and iridescence discussed in this paper. I quote the essentials, with the changes inserted in brackets [ ]:

Alto-cumulus * * *. In the vicinity of the sun or moon diffraction colors are usually visible * * *.

Alto-stratus * * *. On thin parts of the other (water-droplet) kind, diffraction colors appear in the vicinity of the sun or moon.

Cirro-cumulus * * *. *Small white flakes or tenuous globular masses which* [except rarely] *produce no diffraction colors near the sun or moon* * * *. Ci.-Cu. being composed of ice particles [except in their ephemeral earliest stages], are usually bright, in spite of their tenuity, and do not have the solid appearance characteristic of liquid-droplet, A.-Cu. clouds * * *.

The bracketed modifications introduced should, at least partially, meet the criticisms raised by British meteorologists.[52]

Even in their modified form, however, these suggestions are not in conformity with the usual practice abroad, which, as shown in Table 8, is such as to place cirro-cumulus clouds at an appreciably lower elevation than is customary in America, and which, in consequence of the higher temperature and usual water-droplet composition of such clouds, results in the cirro-cumulus being designated twice as often as alto-cumulus when an iridescent flocculent cloud is observed. Hildebrandsson's observations at Upsala and Arendt's at

[48] Cf. Bericht des Internationalen Meteorologischen Comité und der Internationalen Commission für Woljenforschung, Versammlung zu Upsala, 1894, p. 24.

[49] The matter of coronas in the international cloud definitions and national instructions for observers is discussed in detail by E. Leyst, in Höfe um Sonne und Mond in Russland, *Bull. des Natural. de Moscou*, 1906, No. 182, pp. 9–13.

[50] C. F. Brooks, Cloud nomenclature, *Mo. Weather Rev.*, September, 1920, 48: 516.

[51] Idem.

[52] See *Meteorological Mag.*, 1921, 56: 158–9, 192–3, 219–20; 1922, 57:183–4, 211; and *Qu. Jour. Roy. Meteor. Soc.*, January, 1923, 49: 3–4.

Potsdam [53] show, respectively, 40 and 50 per cent of the iridescence observations to have been on cirro-cumuli, as against 24 and 20 per cent on alto-cumuli, while Ci., Ci.-St., and Ci.-Cu. grouped together include 58 and 78 per cent of the cases. In my own observations I have credited cirro-cumuli with only 7 per cent, and alto-cumuli with 45, while Ci., Ci.-St., and Ci.-Cu. together comprise only 11 per cent of the total occurrences of iridescence. Cirro-cumulus and cirro-stratus may feature too seldom in these observations, even though I faithfully attempted to keep strictly to the current International definitions.[54]

We should not forget the fundamental basis of height in our International cloud forms. Therefore, as originally intended,[55] all reasonable care should be exercised to reserve the names cirro-stratus and cirro-cumulus for clouds that are distinctly higher than alto-stratus and alto-cumulus. Thinness and small apparent size of elements in the higher clouds are primary criteria, but the thin and small-size initial phases of the lower ones should not lead the observer to misname them with the names of the higher. The occurrence and angular extent of iridescence seems to provide a hitherto unused aid in differentiating what might be called pseudo-cirro-stratus and cirro-cumulus, which are really alto-stratus and alto cumulus ("* * * finer flakes (resembling Ci.-Cu.)"),[56] from the true and higher types.

Conclusion.—The apparent value of the extent of iridescence as a rough index to temperature, and, therefore, to approximate cloud height, should justify, (1) the regular use of dark glasses by observers, (2) the rough angular measurement of the radii of coronas and the extent of iridescence, and (3) the entry of such observations as an essential part of the cloud record. Furthermore, systematic observations of the heights and temperatures of iridescent clouds should be undertaken at aerological stations, in order to establish the degree to which angular extent of iridescence on different cloud types forming at different rates may be used as an indication of cloud temperature and height.

USING WEATHER FORECASTS FOR PREDICTING FOREST-FIRE DANGER

By H. T. GISBORNE, U. S. Forest Service
[Priest River Experiment Station]

Three kinds of weather control the fluctuations of forest-fire danger—wet weather, dry weather, and windy weather. Two other conditions also contribute to the fluctuation of fire danger. These are the occurrence of lightning and the activities of man. But neither of these fire-starting agencies is fully effective unless the weather has dried out the forest materials so they are dry enough to burn.

Forest fires can not be started and will not spread unless the forest fuels are dry. Wet weather makes the fuels wet, dry weather makes them inflammable, windy weather fans the flames and makes the fires most difficult to control. If the degree of wetness, dryness, and windiness of the weather can be forecast accurately in time and place, fire danger can likewise be forecast with sufficient accuracy to improve very greatly the efficiency of forest-fire detection and suppression. The purpose of the present article is to illustrate some of the detailed procedures involved in the process of translating weather forecasts into fire-danger forecasts for the conifer timber types of northern Idaho and western Montana.

Investigations of the relation of weather to fire danger were initiated in this region by the Priest River Forest Experiment Station in 1916. These first researches were largely devoted to the compilation and comparison of records of weather and forest fires. The report, "Climate and Forest Fires in Montana and Northern Idaho, 1909 to 1919,"[1] by Larsen and Delavan, gives specific data on both weather and fire fluctuations. The present object of fire studies, however, is to make available to the fire-fighting organization all possible information concerning present and probable fire danger so that that organization may expand to meet increasing danger and contract to save unnecessary expense whenever possible.

A forecast of several days of hot, dry weather does not always mean a certain degree of fire danger in this region. The effect of that hot, dry weather depends on how wet the fuels were to begin with. If it has rained recently, a week or more of drying weather may be required before extreme danger will result. Likewise, following a drought, the forecast may be for a period of high humidity, or rain, and the effect will depend on how dry the fuels were to begin with, as well as on how high the humidity may be or how much rain may fall. Before weather forecasts can be used accurately in determining what protective action should be taken, it is necessary to know the prevailing moisture contents of the various fuels.

Studies at the Priest River Forest Experiment Station in northern Idaho have shown that the top layer of duff (decaying leaves and twigs covering the mineral soil) responds to weather changes about as the average of all the combustible forest materials, from moss, weeds, and twigs, to slash and the outside wood on windfalls and snags. The finer and lighter of these fuels pick up and lose moisture rapidly; the heavier fuels, such as branchwood, etc., respond more slowly. The top layer of duff seems to be a reliable criterion of the average response.

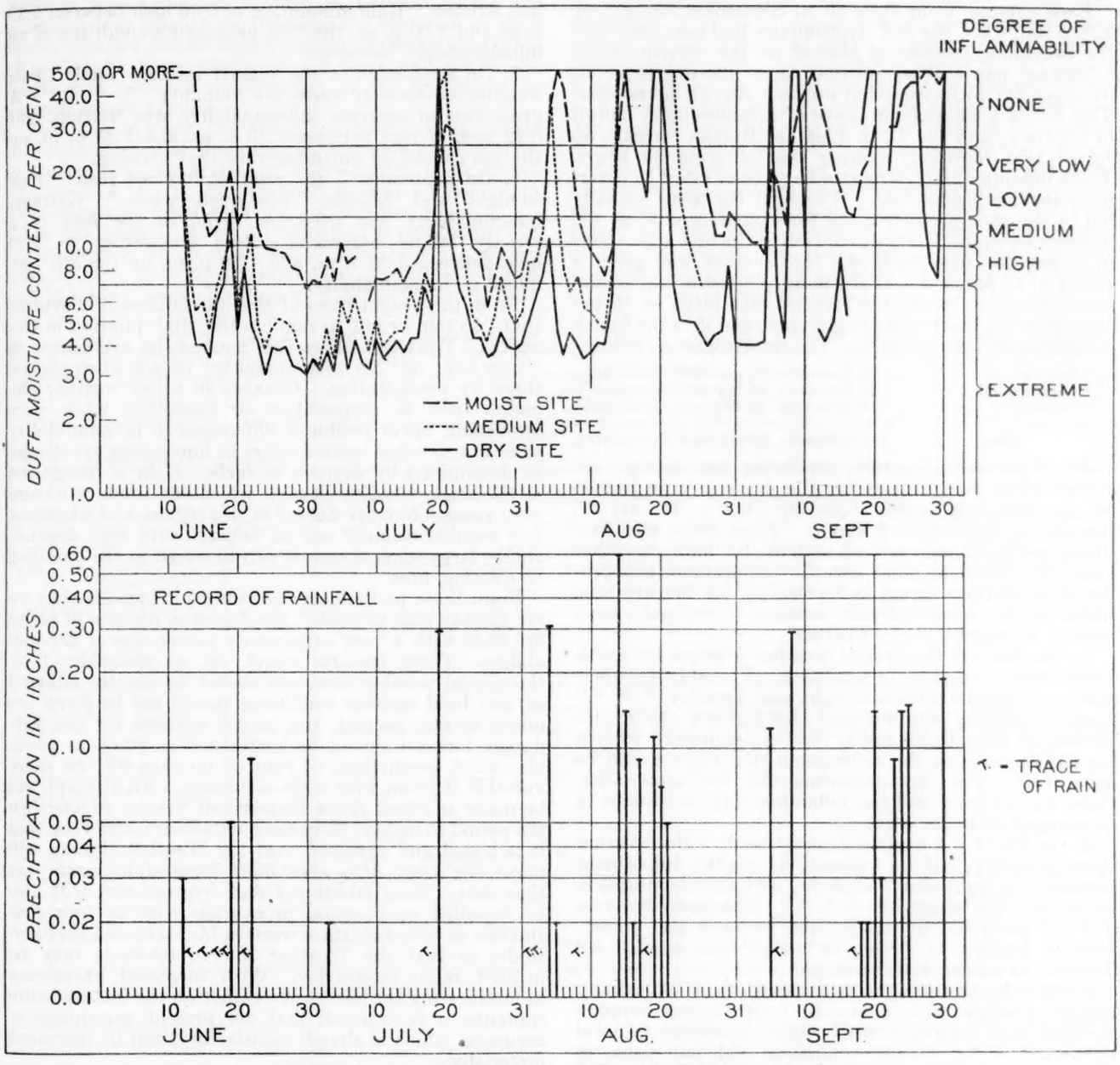
An instrument for measuring the prevailing moisture content in that top layer of duff, called a duff hygrometer, has been invented by the U. S. Forest Products Laboratory and the Priest River Station. Numerous tests of the inflammability of duff in relation to its moisture content have permitted the delineation of six zones of inflammability—none, very low, low, medium, high, and extreme. By this means it is possible to apply weather forecasts to a reliable base and so obtain a translation into terms of fire danger. Past practice has shown that such a translation can not be made with sufficient accuracy without such a base to build on.

During the past fire season (1924) three duff hygrometers were used to measure prevailing duff moisture contents on three different sites in the vicinity of the Priest River Forest Experiment Station in northern Idaho. These three sites may be termed, (1) moist site, a fully timbered northwest slope; (2) medium site, a partially cut-over knoll top; (3) dry site, a clean-cut, fully exposed flat. Figure 1 shows the fluctuations of moisture content recorded, also the various zones of inflammability, as previously described.

As might be expected, these three sites, all within a circle less than a mile in diameter, generally exhibited very different degrees of fire danger, the fully timbered station usually showing the most moisture, the clean-cut area the least, and the partially cut area an intermediate amount. Table 1 shows the percentage of time during which each site experienced the various degrees of inflammability.

[53] Arendt, op. cit., p. 223.
[54] International Cloud Atlas, Paris, 1910.
[55] Cf. Brooks, op. cit.
[56] International Cloud Atlas, Paris, 1910. Part of designation of alto-cumulus.

[1] MO. WEATHER REV., Feb., 1922, 50: 55-68.



INFLAMMABILITY OF FOREST DUFF

Three Sites at Priest River Forest Experiment Station.

FIG. 1.—Relation between the distribution of rainfall and the inflammability of forest duff during the fire season of 1924 near Priest River Forest Experiment Station, Idaho

TABLE 1.—*Percentage of time (June 12 to August 30, inclusive) on which various degrees of inflammability occurred*

Inflammability	Extreme	Extreme and high	Extreme, high, and medium	Extreme, high, medium, and low	Extreme, high, medium, low, and very low	None
Dry site	76	83	86	89	93	7
Medium site	57	74	79	83	85	15
Moist site	5	43	59	68	75	25
Average	46	67	75	80	84	16

From the chart and the table it is evident that both the daily fluctuations and the average inflammabilities on these sites differed considerably, yet the same weather passed over all of them. The fallacy of using measurements of prevailing weather alone as an index of existing fire danger is consequently apparent, if the region contains any variety of topography and timber types. Likewise, a weather forecast which means one degree of danger for one site may mean an entirely different degree on another site.

Each evening from June 30 to September 20, at 5 or 5:30 p. m., when the duff hygrometers had been read and the prevailing conditions plotted on the current chart, a forecast was written down to show the degree of inflammability to be expected on each site 24 hours later. This forecast utilized the zones of inflammability shown in Figure 1, and the U. S. Weather Bureau forecast received that morning covering the following 36 hours. These inflammability forecasts have been rated to determine their dependability. Whenever the point actually fell in the zone predicted, the forecast was rated as 100 per cent accurate. If the point fell in the first zone above or below the one predicted, the forecast was given a rating of 75 per cent. If the point plotted in the second zone, above or below, the forecast was rated at 50 per cent; if in the third zone, 25 per cent; and if in the fourth or fifth zones, zero per cent. The results were as follows:

Dry site	76 forecasts, 82 per cent dependable.
Medium site	55 forecasts, 85 per cent dependable.
Moist site	78 forecasts, 88 per cent dependable.
Total	209 forecasts, 86 per cent dependable.

All of the serious errors, producing zero ratings, occurred when the forecasts for the dry site were framed on the following dates: June 30, July 1, 18, 21, 27, August 13, September 4 and 7. These dates also produced errors, though not all serious, for both the other sites. It is well to point out the conditions which produced the serious errors in forecasting for the dry site, which is the most difficult because it responds most rapidly to changes in the weather.

1. On June 30 the special weather forecast for north Idaho read: "Becoming unsettled. Probably thunderstorms in the mountains tonight and Tuesday * * *." Local conditions substantiated this forecast and a prediction of no inflammability was consequently written for the dry site on the assumption that there would be some rain. The thunderstorms did not materialize, there was no rain, and the inflammability was found to be extreme 24 hours later.

2. On July 1 the weather forecast read: "Hot weather through to-day, will be followed by slightly lower temperatures to-night and Wednesday with thunderstorms in mountains this afternoon * * *." The thunderstorms had not occurred but still seemed probable and a compromise forecast of "High or lower" was written for July 2. It was actually extreme.

3. On July 18 the weather forecast read: "Generally cloudy weather with moderate temperatures through to-night and Saturday with slight possibility of local showers * * *." Local conditions did not seem to favor the "slight possibility of local showers" and a forecast of extreme inflammability was therefore written. A rain of 0.29 inch between 8:30 a. m. and 3:00 p. m. on the 19th resulted in no inflammability.

4. On July 21, contrary to a "fair weather" forecast by the Weather Bureau, but using as a basis the local measurements of pressure, temperature, humidity, and wind direction, a prediction of no inflammability was written. Actually it was extreme.

5. On July 27 the official forecast read: "Cloudy, probably showers to-night and Monday, with thunderstorms in the mountains." No inflammability was forecast; actually it was extreme.

6. On August 13 the weather forecast read: "Showers and cooler to-night and Thursday, probably thunderstorms in mountains." Because of a slightly higher local barometer, a forecast of extreme inflammability was written. Rain amounting to 0.60 inch between 5:30 a. m. and 3:00 p. m. the 14th produced a condition of no inflammability, however.

7. On September 4 the official forecast read: "Fair weather, moderately warm, low humidity * * *." A prediction of extreme inflammability was written, but 0.12 inch of rain between 1:30 a. m. and 1:45 p. m. on the 5th caused no inflammability that evening.

8. On September 7 the weather forecast read: "Fair to-night and Monday, continued warm." Extreme inflammability was predicted, even in the face of a rapidly falling barometer. Rain amounting to 0.29 inch between 5:30 a. m. and 1:30 p. m. on the 8th produced no inflammability.

From these eight cases of absolute failures it is evident that "to rain or not to rain" is the vital question in this region. The chart shows that none of the curves rose to "Very low" or "No inflammability" except when pushed there by precipitation. Changes in other weather elements such as temperature or humidity, while very important, never produced differences in inflammability sufficient to cause serious errors in forecasting fire danger as determined by dryness of fuels. Rain is recognized as the single weather element which can produce a complete cessation of fire danger in this region, and whenever this weather element can be forecast with high dependability large sums of money can be saved in the handling of existing fires.

From these preliminary indications it appears that we are already able to predict the degree of dryness of forest fire fuels with a very satisfactory percentage of dependability. Three features stand out as desirable—first, the official weather forecasts should be strictly adhered to, and local weather conditions should not be given too much weight; second, the period covered by the fire-danger forecast should be lengthened as much as possible; third, predictions of rain or no rain will be more valuable if given with more assurance. An attempt will be made at Priest River Experiment Station to lengthen the period to include 36 instead of 24 hours next year, and it is hoped and expected that the Weather Bureau will name our rainy days even more successfully next year than last. Four additional duff hygrometers will also be installed next season in average sites at four new stations in various parts of western Montana and northern Idaho so that the Weather Bureau forecasts may be utilized more intensively. With increased experience in interpreting the effects of weather on the fuel moisture contents, it is expected that our present percentage of accuracy, which is already satisfactory, can be increased materially.

THE FOREST-FIRE SEASON AT DIFFERENT ELEVATIONS IN IDAHO

By J. A. LARSEN, U. S. Forest Service

[Priest River Forest Experiment Station]

In any fire-ridden forest region, such as north Idaho, there is great need for a tangible basis by which to judge the length and the intensity of the fire season in different forest types and at different elevations. The major and natural forest types, such as the western yellow-pine forests, the western white-pine forests, and the subalpine forests occur in altitudinal zonations one above the other and are the result of differences in air temperature and precipitation which affect not only life, growth, and distribution, but the fire hazard as well. It follows, therefore, that in addition to the local and physical

basis of classifying fire hazard, as determined by the quantity and quality of inflammable material in each forest type, we should be in a position to begin the laying of a climatic basis which will set forth and define the length and possibly the intensity of the fire season in various forest types.

With this in view, the writer has examined variations in temperature and precipitation at different elevations in north Idaho, using data collected by the U. S. Forest Service and the U. S. Weather Bureau. These data have been correlated with the major forest types.

On the basis of a very exhaustive investigation,[1] in the course of which over 13,000 fires, which occurred from 1909 to 1919 in different parts of northern Idaho and Montana, were classified by months and correlated the western white-pine station of Murray, Idaho, 132 days from May 14 to September 23; and Roosevelt, the station in the subalpine region, 76 days from June 25 to September 9. In the subalpine forests the fire season is only half as long on this basis as in the western yellow-pine forests, these periods existing in full measure during dry seasons and being somewhat curtailed by rainfall during the normal seasons. Not only does the western yellow-pine and the lower white-pine forest type show longer fire seasons than the subalpine areas, but during this season much higher air temperatures prevail over these, and this fact materially increases the intensity of the fire season [2] in the lower as compared to the upper forest types. The other factors of climate bearing on the intensity are taken up later.

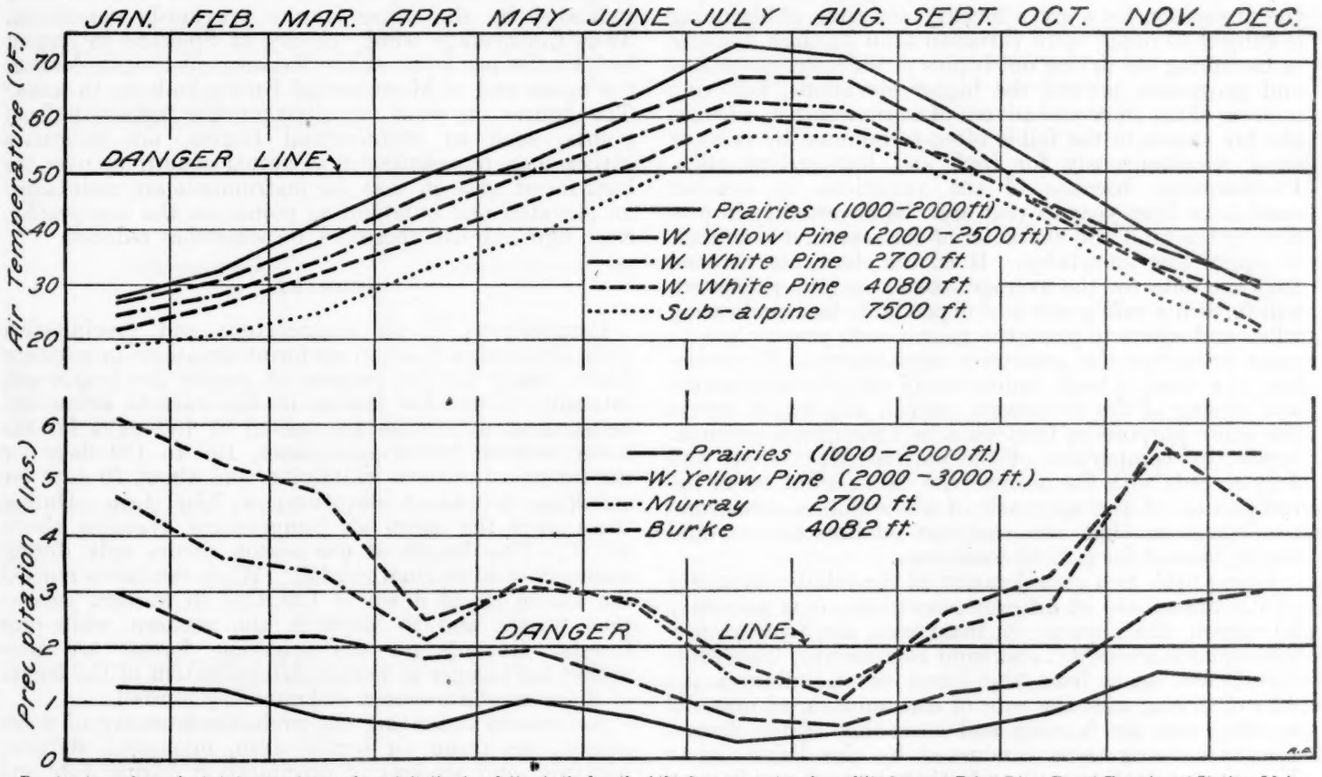


FIG. 1.—Annual march of air temperature and precipitation in relation to the length of the fire season at various altitudes, near Priest River Forest Experiment Station, Idaho

with temperature, it became quite clear that a mean air temperature between 45° and 50° F., but nearer 50°, could be used to fix the beginning and the ending of the fire season. Fifty degrees is therefore used to designate the beginning and ending, as well as the duration of the average fire season. It was also shown in the same report that there is practically no fire danger whenever the monthly precipitation averages 2 inches per month and, furthermore, that whenever the rainfall showed less than 2 inches per month the number of fires was directly proportional to this deficit under 2 inches. The danger line in precipitation is therefore fixed at 2 inches per month.

Looking over the air temperature data and curves for indications of the length of the fire season, it is seen that the western yellow-pine stations show a possible fire season of 150 days extending from May 4 to October 2;

It was stated above that an average rainfall of 2 inches per month during summer holds fires well in check. Since, however, the normal rainfall curves for Idaho go considerably below this point, both in the yellow-pine and the white-pine forests, there is, therefore, a fire season during every summer of normal as well as subnormal precipitation, and a safe season occurs only during the years of abnormal rainfall. The length of the fire season in the western yellow-pine forests, as gaged by the normal rainfall curves, Figure 1, extends from May 15 to October 31, seemingly a period of 168 days, but from this we must deduct 29 days in October in which the temperature is so low that there is really no great danger. This leaves a period of 139 days. We may say, therefore, that under conditions of normal precipitation there is, in the western yellow-pine forests, a fire

[1] "Climate and Forest Fires in Montana and Northern Idaho," by J. A. Larsen and C. C. Delavan, MO. WEATHER REV., Feb. 1922, 50; 55-68.

[2] The phrase *intensity of the fire season* is used in designating whether or not a season is characterized by, for instance, great length and numerous large and destructive fires, or by few fires and relatively small damage, etc.—*J. A. L.*

season of 139 days limited by the rainfall in the spring and the temperature in the fall, and in years of deficient rainfall a fire season of 150 days limited by temperature conditions both in the spring and fall. In the lower station for the western white-pine forest the fire season is similarly limited during seasons of normal rainfall to 67 days from July 1 to September 5, and during summers of subnormal rainfall from May 14 to September 23, a period of 132 days.

Unfortunately, there is no available normal rainfall curve for subalpine forest stations in northern Idaho. Roosevelt, which lies at 7,500 feet, could be compared for temperature but not for rainfall, because it lies too far to the south on a watershed which shows rainfall conditions different from north Idaho.

It should be remarked that in judging the length of the fire season for a given locality, the time of beginning is subject to much more variation than its close, because in the spring the drying out begins at the lower elevations and progresses toward the higher elevations, following melting of the snow and advent of warm weather, whereas the fire season in the fall is often terminated by rains or snow simultaneously for high and low regions alike. Furthermore, because of the variations in weather conditions from year to year and the uncertainty in predicting the kind and character of the season, it is difficult to apply this knowledge. It is, therefore, not claimed that the data for the average season, as here presented, will furnish a safe guide and dependable basis indicating when and where to place the guards each year or how to mass or scatter the protective organization. Nevertheless, the chart is fairly indicative of the average opening and closing of the fire season, and in this way it serves the same purpose as frost data in agricultural pursuits. Again, by comparison of the current May, June, and July records with the normal, the data should aid in the recognition of the approach of abnormal or subnormal conditions so that the cautious administrator would fortify himself for critical conditions.

Going back to a consideration of the relative intensity of the fire season at different elevations, it is necessary to regard the factors of maximum air temperature, atmospheric humidity, and wind movement. (See Table 2). These, aside from the forest cover, influence the rate of drying out, the rate of consumption of material by fire, and the fanning and spreading of the flames. Recent investigations conducted by the Priest River Experiment Station staff and others have shown beyond a doubt that the dryness of the air in summer greatly influences the rate of spread of forest fires.

Although data on these factors are not as complete as could be wished, certain outstanding and significant figures have been obtained. Thus the mean maximum temperatures in August in the yellow-pine forests are about 10° higher than in the western white-pine forests, and nearly 20° higher than at the lookout points above 6,000 feet elevation.

Since the critical conditions for forest fires are as much a result of deficient rainfall as high temperature, it is well to consider the amount of rain which falls during the summer, or, better yet, during the two months, July and August. For the western yellow-pine forests this is only 1.30 inches and in the western white-pine forests 2.71 to 2.75 inches, or 0.65 per month in the yellow-pine type and 1.38 inches per month in the western white-pine type. During years of unusually bad forest fires, such as 1910 and 1919, the total July and August rainfall has been considerably less than 1 inch for these two months, both in the yellow-pine and in the white-pine forests.

The relative humidity also shows much more dangerous conditions in the yellow-pine forest than elsewhere. But while the low lying regions show both a longer and more intense fire season than the higher, the latter are subject to much greater wind movement than low stations and are for this reason not as well off as is indicated by the other factors previously considered. Thus the average wind velocity at Spokane in August is 5.3 miles per hour, at the Experiment Station lookout 8.9 miles, and at Monumental Buttes lookout 15 miles.[3] The figures on wind velocities at the highest lookout points, such as Monumental Buttes, are indicative rather than representative of actual conditions over the high forest area, in that the instruments are maintained on elevated and outstanding points on the topography. Such figures must, therefore, be somewhat reduced

SUMMARY

Comparisons of air temperature and precipitation data obtained in the various forest zonations in northern Idaho, made for the purpose of gaging the length and intensity of the fire season in the various altitudinal belts, show a possible fire season of 150 days for the lower western yellow-pine forest, 107 to 132 days for the forests of western white-pine, and about 76 days for subalpine forests at elevations of 7,500 feet. During these days the mean air temperature averages above 50° F. This length of fire season occurs only during summers of subnormal rainfall. When rainfall is normal the season is cut down to 139 days in western yellow-pine forests and 67 days in the western white-pine forests. Records for the subalpine forests are altogether too meager to permit determination of the length of the normal fire season as limited by rainfall.

As criteria indicating the probable intensity of a fire season, the mean air temperature, maximum air temperature, and amount of precipitation during July and August, as well as the relative humidity, appear to be much more critical in the lower western yellow-pine forests than on the forests which appear at higher elevations. Wind movement is greatest in the subalpine forests and lowest in the western white-pine type, and were it not for the low temperature and high humidity occurring at the higher elevations, the fire hazard would be much greater in the subalpine type than is actually the case.

[3] The relation of air temperature, wind movement, and relative humidity on lookout stations in Idaho and the comparison of these with conditions at valley stations is more completely set forth by the author in the Journal of Forestry, vol. 20, No. 3, Mar., 1922, p. 215–219.

TABLE 1.—*Mean monthly and annual air temperatures, precipitation, and length of fire season (days) for the period 1909–1919, northern Idaho and Montana*

Zonation	Station	Elevation	Mean air temperature (°F.)												Length of fire season		
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Beginning	Ending	Days
		Feet																
Prairies of eastern Washington.	(1)	1,000–2,000	27.7	32.6	41.6	49.9	57.1	63.7	72.5	70.9	61.6	50.6	39.0	29.9	49.7	4/15	10/16	184
Western yellow-pine forest	(2)	2,000–2,500	27.2	31.0	37.7	46.1	53.1	60.3	66.8	66.7	57.4	44.5	36.7	30.3	46.4	5/4	10/2	150
Western white-pine forest	Murray	2,700	25.2	28.5	34.4	43.2	50.4	56.4	62.9	61.7	52.2	44.0	33.4	27.4	43.3	5/14	9/23	132
Western white-pine forest	Burke	4,080	22.0	26.4	32.3	38.6	44.8	51.4	59.9	58.2	53.2	43.2	33.0	22.4	40.4	6/8	9/23	107
Subalpine forest	Roosevelt	7,500	19.2	21.4	25.0	32.7	38.3	47.6	56.6	56.6	48.9	41.0	27.8	22.0	36.4	6/25	9/9	76
			Precipitation (inches)													July–Aug.	June–Sept	
Prairies of eastern Washington.	(1)	1,000–2,000	1.30	1.25	0.76	0.55	1.04	0.76	0.31	0.45	0.48	0.83	1.54	1.42	10.69	0.76	2.00	
Western yellow-pine forest	(2)	2,500	3.01	2.18	2.22	1.82	1.96	1.36	0.73	0.57	1.18	1.49	2.77	2.97	22.39	1.30	3.84	
Western white-pine forest	Murray	2,700	4.72	3.62	3.34	2.13	3.27	2.72	1.38	1.37	2.31	2.75	5.71	4.40	37.72	2.75	7.78	
Western white-pine forest	Burke	4,080	6.17	5.30	4.78	2.50	3.09	2.84	1.68	1.03	2.62	3.27	5.48	5.48	44.24	2.71	8.17	
Subalpine forest	Roosevelt	7,500	2.81	3.01	3.92	1.40	2.03	2.33	1.48	0.82	0.94	1.12	2.46	3.80	26.02	2.30	5.57	

[1] Ritzville, Hatton, and Lind, Wash.
[2] Spokane, Coeur d'Alene, and Potlatch, Idaho.

TABLE 2.—*Averages and extremes of weather conditions in August*

Forest zone or type	Place and elevation (feet)	Air temperature (° F.)			Relative humidity (per cent)			Wind movement (miles per hour)	
		Absolute maximum	Mean maximum	Mean minimum	Mean a. m.	Mean p. m.	Lowest monthly	Mean for month	Maximum monthly
Prairies of eastern Washington	Hatton, 1,100	112	88.8	49.2					
Western yellow-pine forest	Spokane, 1,943	105	82.3	53.6	64	25	16	5.3	6.5
Western white-pine forest, low station	Priest River, 2,380	101	81.6	41.8	65	39	24	2.7	6.0
Western white-pine forest, low station	Murray, 2,700	97	80.1	43.3					
Western white-pine forest, high station	Burke, 4,082	92	74.4	42.0					
Subalpine forest	Experiment station lookout, 6,000		68.6	51.0	60	46		8.9	
Subalpine forest	Monumental Buttes, 6,979		72.6	49.1		53	30	15.0	

A PRELIMINARY STUDY OF EFFECTIVE RAINFALL

By J. F. VOORHEES

[Weather Bureau, Knoxville, Tenn.]

SYNOPSIS

Since the water content of the soil does not change appreciably from year to year, each year's rainfall must escape in some manner.

In winter it escapes by evaporation and run-off in streams.

In summer it escapes by evaporation, by run-off, and by transpiration.

Transpiration may be increased at the expense of run-off by increasing the number and vigor of plants.

It appears that the possible effective rainfall for this region will average from 6 to 8 inches per year, which is enough to double the present average yield.

The above title was chosen because this paper is mainly an effort to analyse the problem and indicate the most promising line of attack; and because the data at hand were so general that we could hope to reach only general conclusions. It is believed that a more detailed study, using daily instead of monthly values, would throw much additional light on the subject.

Assuming that in any given region the water content of the soil does not change materially from year to year we are confronted with the fact that each year's rainfall disappears somewhere during the year. This is true whether there are plants present or not, and the object of this study is to learn what part of this water may be diverted for the use of plants. We shall attempt to make this determination by means of a comparison of total rainfall with run-off, supplemented by some data on leaching from the University of Tennessee Experiment Station, and by some data on evaporation from trees, obtained by the author.

It would seem that all of the rainfall can be accounted for in one of the following ways:

a. Evaporation from plant surfaces before reaching the ground.

b. Evaporation from the surface of the soil before penetrating to an appreciable depth.

c. Evaporation in the soil below the surface.

d. Surface drainage.

e. Subsurface drainage or leaching.

f. Transpiration.

Evaporation from plant surfaces.—A set of observations made by the writer under a cherry tree about 20 feet high and 18 feet in diameter showed that the bare tree with no leaves would prevent about 0.10 inch of water from reaching the ground during each rain. A rain gage was set under the tree and another about 25 feet away in the open. A collar was fitted around the trunk of the tree in the form of a trough with a spout, under which a tub was set. The tub was covered so that no direct rainfall or drippings from the tree could enter it.

The water that ran down the trunk of the tree and was caught in the tub plus the water caught in the rain gage under the tree always lacked about 0.10 inch of equaling the amount caught in the gage in the open. In the summer when the trees are in leaf the amount of precipitation failing to reach the ground would undoubtedly be greater.

When we come to farm crops the importance of loss may seem less evident, but since all the mechanism of plant surfaces is adapted for the elimination of water rather than for its absorption, and since it has been shown experimentally that plants will die if the roots are dry, no matter how wet the stem and leaves may be kept, it seems probable that at least as much would be lost here as was lost under the leafless tree.

Evaporation from the surface of the soil before soaking in.—It is the opinion of a number of men who have been consulted that a rainfall of 0.10 inch will practically always evaporate without penetrating the ground appreciably. If this is true it would seem permissible to assume that an equal amount is lost from each heavier rain. Evaporation from these sources will amount to an inch or more of rain per month for the winter months, and in the summer months this evaporation, supplemented by the *evaporation within the soil* will certainly not be less, and will probably be much greater.

Surface drainage.—Water lost by this method has never been measured by itself as far as the writer knows, but is included in the run-off of the streams, which has been measured.

Loss of water by subsurface drainage.—This may also be assumed to be included in the run-off of streams, with the possible exception of a portion that may reach the river at a point below where the flow of the river was measured.

As a check on this point, data obtained in a lysimeter experiment at the University of Tennessee Experiment Station were used. The data used were obtained from four iron cans one five-thousandth of an acre in area and 6 feet deep. Three were filled with soil, 5½ feet of subsoil and one-half foot of top soil, all well packed. The fourth can, used as a check on the rainfall, was empty. All were set nearly flush with the ground and so arranged that leachings would drain into receptacles in a near-by pit. The cans were set up in March, 1916, but as we had no run-off data for 1917 and 1918 the years 1919 to 1922 were used in this comparison. It would seem that in that length of time the soil in the cans would have reached an approximately normal condition. As there was no surface drainage, the leachings should equal leaching plus surface drainage in the field, and this should equal the run-off in the river unless an appreciable amount had escaped from the watershed through underground channels. The percentage of leaching for the cans and of run-off for the watershed for four years was as follows:

Year	Run-off	Leaching	Difference
	Per cent	*Per cent*	*Per cent*
1919	43	54	9
1920	41	47	6
1921	43	43	0
1922	45	45	0

Apparently the soil in the cans was not fully stabilized until after 1920, but it seems fair to assume from these results that a negligible amount of water escapes from the watershed underground.

We may now combine some of the ways in which water escapes from a region so that we have two methods in winter and three in the summer: In winter, evaporation and stream run-off; and in summer, evaporation, run-off, and transpiration. Now, since the amount of water lost by evaporation can not conceivably have any great effect upon transpiration, it is evident that as transpiration increases run-off will decrease.

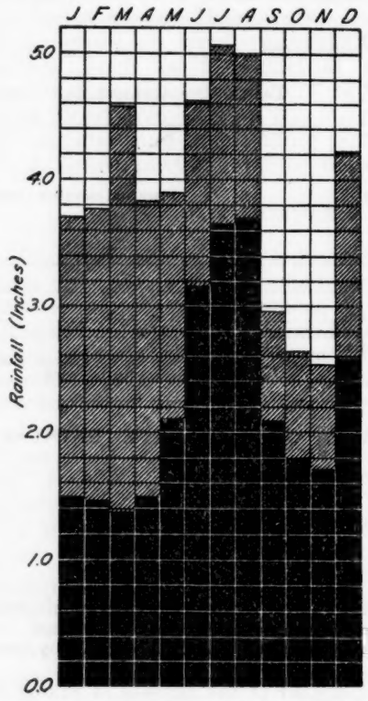


FIG. 1.—Monthly means of total rainfall and run-off, Knoxville, Tenn. Height of column shows total rainfall, upper shaded portion the run-off, lower black portion the remainder lost by evaporation or used by plants

We are now ready to consider our principal lines of data which are total rainfall and run-off. The run-off data were furnished by Mr. Warren R. King, of the hydrographic office at Chattanooga, and consist of the monthly run-off of the Tennessee River at Knoxville in inches for the drainage area of 8,990 square miles. These data cover the period 1900 to 1922, inclusive, excepting the years 1917 and 1918.

The rainfall data were computed from the published records of the Weather Bureau and include all stations in this drainage area. During the earlier years there were only 10 stations, but the number gradually increased until there were 20 for the later years of the series.

Fig. 1 shows the monthly means for total rainfall and run-off for the entire period of 21 years. The upper shaded portion represents the run-off, while the lower black portion represents the remainder of the rainfall which is lost by evaporation or used by plants.

TABLE 1.—*Monthly rainfall and run-off, in inches, at Knoxville, Tenn.*

Year	January		February		March		April		May		June		July		August		September		October		November		December		Annual		
	Rainfall	Run-off	Rainfall	Run-off	Rainfall	Run-off	Rainfall	Run-off	Rainfall	Run-off	Rainfall	Run-off	Rainfall	Run-off	Rainfall	Run-off	Rainfall	Run-off	Rainfall	Run-off	Rainfall	Run-off	Rainfall	Run-off	Rainfall	Run-off	Difference
1900	2.41	1.15	5.19	2.12	4.45	3.62	3.22	1.89	2.07	1.05	6.28	1.62	4.11	1.27	2.93	0.71	3.06	.65	2.22	.88	4.00	1.24	3.28	1.40	43.22	17.60	25.62
1901	3.98	2.24	1.25	1.44	4.78	2.10	5.36	4.63	6.62	4.17	5.13	2.83	2.96	1.51	12.52	4.38	3.03	1.92	1.77	1.10	1.02	0.67	9.68	4.17	58.06	31.66	26.40
1902	2.82	3.00	5.52	2.81	4.75	5.86	1.89	2.43	2.17	1.38	6.68	1.36	2.68	1.28	2.69	.66	4.86	.66	2.10	.64	2.86	.68	3.06	1.24	42.08	22.00	20.08
1903	2.18	1.30	7.38	3.58	4.71	4.95	6.12	5.22	2.26	1.53	4.21	1.65	4.19	1.02	4.05	.82	.91	.41	1.92	.34	3.17	.53	1.71	.49	45.31	21.84	23.47
1904	2.26	.72	3.26	1.15	5.43	2.85	2.54	1.32	2.90	1.36	3.85	.83	3.32	.77	3.84	.83	1.50	.41	0.07	.25	3.27	.36	3.45	.83	35.69	11.68	24.01
1905	3.17	1.60	4.40	2.68	2.64	2.09	3.53	1.58	5.48	2.33	4.02	1.15	6.38	2.03	6.16	1.86	1.29	.73	3.17	.56	0.84	.43	5.51	1.65	46.59	18.69	27.90
1906	5.78	3.12	1.08	1.59	4.25	2.10	2.60	2.05	3.52	1.58	5.72	1.51	7.07	1.67	5.38	2.27	4.52	2.56	2.82	2.51	3.76	2.48	3.74	1.96	50.24	25.40	24.84
1907	.95	1.86	2.46	1.34	3.52	2.44	3.83	2.03	3.54	1.75	3.58	2.76	4.13	1.44	3.57	1.05	6.25	1.29	1.52	.78	4.97	1.55	4.14	1.72	44.46	20.01	24.45
1908	4.27	2.26	3.60	2.72	4.22	3.33	4.36	2.52	4.06	1.78	3.35	1.25	5.50	1.23	5.87	1.35	1.80	.68	5.66	1.08	2.05	1.14	5.64	2.41	50.38	22.75	27.63
1909	7.76	2.10	4.85	2.88	5.95	3.98	3.79	1.91	5.70	3.01	7.56	2.79	5.36	1.97	4.20	1.36	3.26	.80	2.77	.70	0.56	.45	2.83	.68	49.54	22.63	26.91
1910	3.38	1.23	3.17	1.31	1.15	1.29	3.02	.77	5.10	1.30	4.32	1.22	6.62	1.59	5.72	.96	3.72	1.44	2.14	.61	1.30	.38	3.54	1.05	43.18	13.15	30.03
1911	3.81	1.91	3.40	2.31	4.62	2.21	6.05	3.30	1.46	1.26	2.68	.62	3.82	.62	4.29	.43	2.70	.49	4.53	.80	3.42	.80	2.66	1.20	44.44	16.15	28.29
1912	2.48	1.23	3.32	1.86	5.92	3.68	6.30	3.68	4.44	2.26	4.64	.99	5.72	1.38	4.01	.84	3.78	.62	1.65	.52	1.95	.51	3.06	.63	46.27	18.00	28.27
1913	5.24	2.42	3.75	1.66	7.10	4.54	2.85	1.90	5.75	2.03	3.44	1.30	2.81	.64	3.49	.59	4.10	.51	2.54	.52	1.52	.51	2.64	.59	45.23	17.21	28.02
1914	1.95	.74	3.35	1.31	4.21	1.65	3.94	2.29	1.37	.86	3.23	.57	5.09	.52	4.86	.59	1.76	.39	4.05	.82	2.70	.47	7.35	3.00	43.86	13.21	30.65
1915	3.96	2.77	3.55	2.31	2.40	1.19	1.46	.89	5.65	1.05	4.80	1.03	4.64	1.29	5.16	.77	3.37	.79	2.89	1.02	3.29	.82	5.95	2.65	47.12	16.58	30.54
1916	4.37	3.61	4.39	2.70	3.11	2.25	2.22	1.42	3.84	.90	4.63	1.05	10.89	4.06	4.85	1.80	2.20	.64	2.47	.60	1.96	.49	3.01	1.03	47.94	20.55	27.39
1919	4.98	3.64	2.90	1.96	3.64	2.65	3.22	1.55	4.98	2.13	5.27	1.41	3.48	1.15	3.82	.85	1.20	.45	4.77	.81	1.58	.56	3.62	1.83	43.46	18.99	24.47
1920	3.52	1.78	3.51	2.01	5.95	3.75	6.07	4.05	2.43	1.27	5.34	1.34	4.68	1.03	8.73	2.25	4.23	1.45	0.63	.67	3.60	.86	5.15	2.50	54.04	22.96	31.08
1921	3.86	2.25	4.28	3.43	2.59	1.61	3.85	1.92	3.84	2.01	3.96	1.13	6.72	1.60	5.37	1.95	2.81	.76	2.46	.56	3.77	1.02	2.43	1.45	45.94	19.66	26.28
1922	4.72	2.94	4.11	2.67	7.00	4.22	4.50	2.66	4.52	2.82	4.12	1.44	6.26	1.71	3.34	.89	1.43	.55	2.67	.52	1.22	.40	6.92	2.19	50.81	23.00	27.81
Means	3.70	2.19	3.76	2.29	4.57	3.20	3.84	2.34	3.90	1.79	4.61	1.42	5.07	1.40	4.98	1.27	2.94	0.85	2.61	0.81	2.52	0.81	4.25	1.66	46.55	20.03	26.52
Difference	1.51	-----	1.47	-----	1.27	-----	1.50	-----	2.11	-----	3.19	-----	3.67	-----	3.71	-----	2.09	-----	1.80	-----	1.71	-----	2.59	-----	-----	-----	-----

In considering this figure it must be remembered that while the shaded portion shows the actual run-off for each month at the gaging station,it does not show accurately the part of each month's rainfall that ran off, because a part of the run-off from one month's rain does not reach Knoxville until some time in the next month. A study of the table will reveal a number of instances when the rains of one month showed in the run-off of the next. Without daily values it has not seemed practicable to determine the exact amount of this shift. As a matter of fact the shift itself is often modified by the character of the rainfall. Five inches of rain falling at an excessive rate between the 20th and 25th of any month would mainly pass Knoxville in that month, as there would be a high percentage of surface drainage; but the same amount spread evenly over the same five days would not arrive until the month following, and in winter might even be as much as two months late.

Turning again to our figure and remembering our conclusion that the winter rainfall disappeared either in the run-off or by evaporation, we find that the amount evaporated during the first four months of the year, or before there is any appreciable plant growth, is approximately 1.5 inch per month, or a little more than was calculated from other considerations. For the next four months the run-off rapidly decreases while the rainfall increases just as rapidly. This decreasing run-off under such circumstances must be due to one or both of two causes—transpiration and increased evaporation.

During the fall months the rainfall and the run-off both decrease about 40 per cent, while evaporation probably remains a little above the winter average and transpiration becomes very small.

December, the first wet month following a series of dry months, shows some peculiar characteristics. Although transpiration has practically ceased and evaporation might be expected to show more of the winter characteristics, there is a marked increase in the amount of water that does not appear in the river. There are two reasons why this indicated increase is more apparent than real. First, the amount of run-off carried over from December to January is undoubtedly much greater than the amount brought from November into December. Second, the abnormally dry condition of the fall, with its failing springs and drying wells, is being changed to the normal winter condition of saturation. This probably requires a large part of the extra inch of rainfall that does not appear in the run-off.

Under present farm methods the average crop uses from 3 to 4 inches of rainfall. The run-off during the period of active transpiration of any crop will average from 4 to 6 inches, and if the crop is to be increased it must capture a part of that run-off. This can not be done by the mechanical prevention of surface drainage, because that would only increase the amount leaching through, as was shown in the lysimeter experiment explained above. It was also found in this experiment that all leaching occurred within 48 hours after the rain ended.

Apparently, then, the only way to make use of a part of this surplus rainfall is to increase the quantity of roots in the soil. This increased root growth will get more water in two ways. It will catch some in transit, as it were, before it gets out of reach, and it will reduce the water content of the soil to a lower level between rains, thus requiring more to saturate it again when the next rain comes. This process involves the danger that if rains come too far apart the crop may suffer.

Since it is not likely that it will ever be possible to utilize all of the present run-off, and since this run-off averages only from 4 to 6 inches during the active transpiration season of most crops, it appears that we can not hope to more than double the average yield in this section. This conclusion agrees with the experience of the University of Tennessee Experiment Station, where it has been found that about twice the average yield for the region seems to be their limit for production.

40160—25†——2

A RAIN-GAGE OF STANDARD COMMERCIAL MATERIALS AND PARTS

By BENJAMIN C. KADEL

(Read before a meeting of the American Meteorological Society, January 3, 1925, Washington, D. C. The title of this paper as printed in the program of the meeting was "A proposed dimension for rain-gage collectors")

SYNOPSIS

To meet the need for a rain-gage that may be constructed of materials available in any community, it is proposed to make the collector 5.359 inches in diameter so that one-hundredth of an inch of rain in the gage will equal one fluid dram, thus permitting the water to be measused in a commercial graduate such as may be found in drug stores. Exactness in construction is required in but one part, a small brass ring at the top, and the cost is correspondingly lessened. Features shown by experience to be important are retained. Description and illustrations in enough detail to show how to construct the gage are given.

In English-speaking countries the recognized unit employed in rainfall measurement is one-hundredth of an inch, and it has been the practice to make gages 5, 6, 8, 10, or 12 whole inches in diameter. The quantity of water representing one-hundredth of an inch in a gage of any of these diameters is arbitrary, and hence its measurement requires either a specially constructed measuring tube and stick or a specially made graduate with arbitrary scale divisions, none of which are obtainable through ordinary channels of trade.

However, if a gage be so constructed that the amount of water represented by the unit of measurement agrees with an established unit of capacity, the measuring vessel employed in commercial transactions, and hence available almost anywhere, may be used to measure the rainfall. Upon examining the various established units the fluid dram is found to be suitable to the purpose, as it is large enough to permit identification, and at the same time the number of fluid drams corresponding to an ordinary rain is a quantity of water that may be easily handled. The corresponding gage diameter, 5.359 inches, is within the limits set by the results of experiments as desirable and being nearer the smaller limit involves a smaller amount of materials, which in turn means lower cost.

The degree of accuracy reasonably expected in measuring liquids may be taken from the tolerances given in Bureau of Standards Circular No. 61, with suitable application to the particular vessel in use. A few examples will show how the tolerances would affect rainfall measurements made in conical glass graduates such as are used in drug stores, and in some common commercial vessels.

Vessel	Capacity, rainfall	Probable error
	Inches	*Inches*
1-ounce conical graduate	0.08	0.002
2-ounce conical graduate	.16	.003
8-ounce conical graduate	.64	.007
1-gill commercial measure	.32	.02
½-pint commercial measure	.64	.02
1-pint commercial measure	1.28	.03
1-quart commercial measure	2.56	.04
½-gallon commercial measure	5.12	.06
½-pint milk bottle	.64	.02
1-pint milk bottle	1.28	.03
1-quart milk bottle	2.56	.04

In using the larger graduates there is an additional source of error in the need for eye interpolations between the markings, which are 1 fluid ounce, or 0.08 inch, apart. It is therefore best to use the smaller graduate. In actual trial a 16-dram graduate purchased at a drug store in Washington for 60 cents has been found to be quite satisfactory, although somewhat tedious to use in the case of heavy rains, because repeated fillings are required. However, an observer possessed of a graduate may easily calibrate several bottles of different capacity as an aid to expeditious measurement.

The following typical test shows the degree of accuracy with which water can be measured to fluid drams in a graduate marked in half ounces up to 4 ounces and in whole ounces from 4 to 16 ounces:

Actual drams (precise)	Reading (ounces), conical graduate	Drams, conical graduate	Correction, if rainfall were measured
1.35	½	1	0
2.4	¾	2	0
5.1	2½	4	+0.01
14.8	1⅞	15	0
26.5	3⅜	27	−0.01
40.2	4⅞	39	+0.01
52.6	6⅛	52	+0.01
64.3	8	64	0
82.9	10⅜	83	0
99.1	12⅜	100	−0.01
122.8	15⅜	123	0

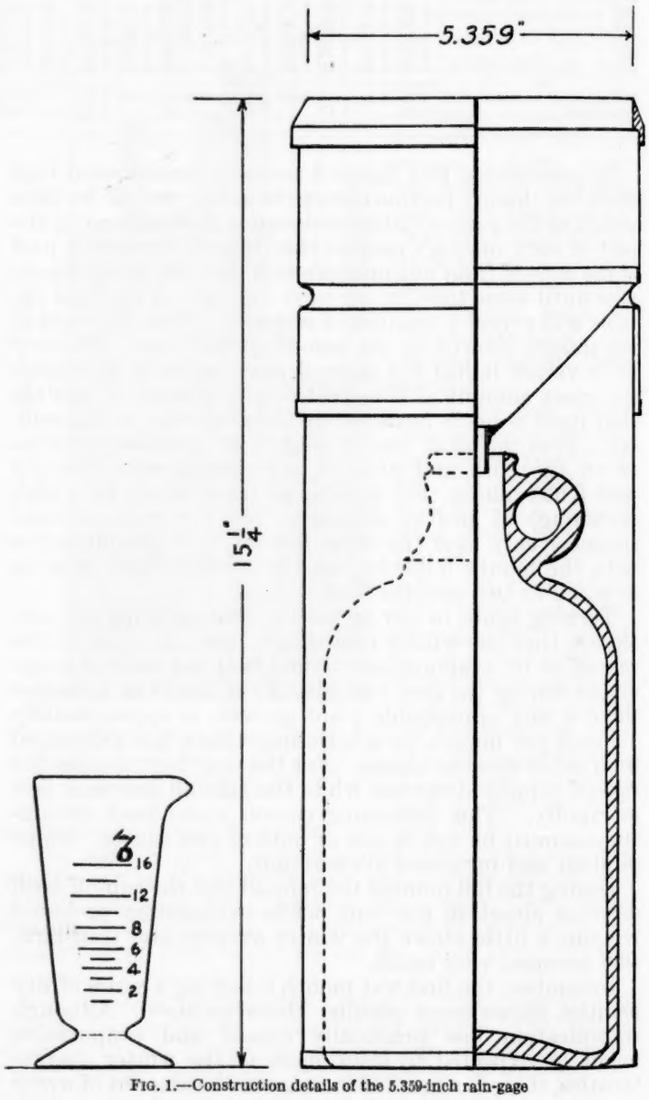


FIG. 1.—Construction details of the 5.359-inch rain-gage

A number of additional trials by different observers gave similar results, and the conclusion is that since the errors are well within the degree of accuracy expected in rainfall measurement the method is practical. A few actual rainfalls have been satisfactorily measured in a gage constructed in accordance with this plan. It is

(To face p. 67)

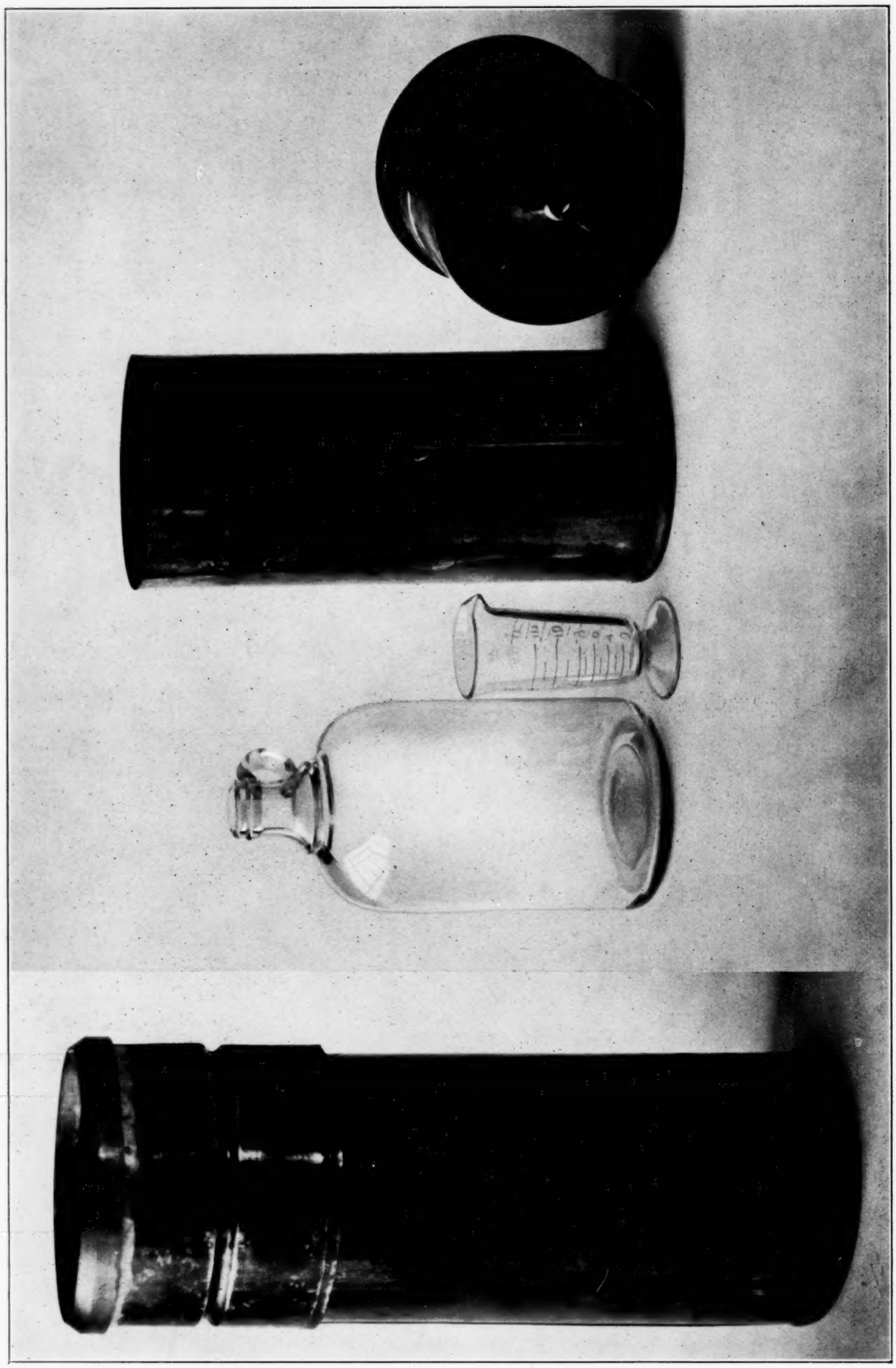


FIG. 2.—The rain-gage unassembled and assembled

recognized that a cylindrical graduate tapered at the bottom and having a capacity of 50 drams or more would be convenient; but it would probably not be found in the open market. A detailed description of the gage, with illustrations follows. A model is also available for examination at the Weather Bureau office in Washington.

DESCRIPTION OF FLUID DRAM RAIN-GAGE

The assembled gage is cylindrical, with outside diameter 5⅞ inches, and over-all height 15¼ inches, designed upon the general plan of the Snowdon rain-gage, well known in England, but with dimensions and parts chosen with a view to construction from standard material. The complete instrument consists of the following parts:

1. *The body.*—This is a sheet copper, cylindrical can, 12 inches deep, and with diameter as near to 5.359 inches as is practicable in construction. This can may also be used as a snow gage. Remembering that the probable error in the catch of snow is much greater than in the catch of rain, it will be apparent that if the diameter of the copper can approximates the above value, snow collected in it may, when melted, be measured in the glass graduate.

2. *The funnel collector.*—This is a sheet-copper cylinder 5.6 inches inside diameter by 4½ inches long, with the funnel proper soldered to the sides halfway up. The upper half of the cylinder gives depth to the collector. The lower half telescopes over the gage body for a distance of about 2 inches. The funnel proper is made with a 45° slope to a central outlet formed by soldering in a piece of brass tube ⅜-inch inside diameter by 1-inch long to form a discharge spout that terminates about 1 inch below the lower rim of the cylinder. A groove rolled in the cylinder serves to provide a definite stop for the funnel proper, gives additional stiffness to the construction, and forms a stop when the funnel is placed in position on the gage body. To the top of the funnel is soldered a stiff brass ring. This ring is important since it defines the area of collection. Its inside diameter must be turned true to 5.359 inches, with assurance that the actual result is within 0.01 inch of the specified diameter, and from the top the metal must be cut away to produce a slant outward and downward about 60° below the horizontal in a way to form a knife edge to "split the drops of rain." The brass ring is rabbeted out one-eighth inch on its lower inner side to form a recess into which the copper funnel may be soldered. Probably the best procedure is to have a molder make a solid cast brass ring three-fourths inch high by three-eighths inch thick by 5⅞ inches outside diameter and have a good machinist do the finishing work.

3. *The retaining bottle.*—This is simply a half-gallon commercial glass vinegar jug intended to hold the rain and prevent evaporation until a measurement is made. If it should be broken through freezing or otherwise another may easily be obtained. It centers loosely in the gage body, thus directing the discharge spout from the funnel into the neck of the bottle without special effort.

4. *The graduate or measuring vessel.*—It is best to have a graduate marked in fluid drams because of the greater accuracy attainable. However, the total capacity of a graduate so marked is generally only 16 fluid drams, and hence it is a good plan to have at hand several auxiliary bottles which may be calibrated by pouring into them from the accurate graduate enough water to bring the height to a point which should be marked in the neck. These calibrated bottles expedite the measurements of heavy rains. Actual trials by different observers have demonstrated that in 16-ounce graduates marked in fluid ounces the necessary eye interpolations between the lines can be made with a reasonable degree of accuracy. Readings are always made by looking horizontally across the lowest part of the curved meniscus of the water surface.

5. *Conversion.*—In a gage constructed as above 1 fluid dram equals 0.01 inch, 1 fluid ounce equals 0.08 inch, 1 pint equals 1.28 inches, 1 quart equals 2.56 inches, one-half gallon equals 5.12 inches. In case of an unusually heavy rain the jug may overflow, but we still have a reserve capacity in the can to care for a total rain of 10 inches.

6. *Cost.*—The cost of a sample gage made according to these specifications was as follows: Copper body and funnel, $4; brass rim, $1.78; retaining bottle, $0.15; 16-dram graduate, $0.60; total cost, $6.53; overhead and profit not considered.

7. *Manufacture.*—The best method of construction is to have the entire gage made by a competent manufacturer of meteorological instruments; but where such manufacturers are not accessible the brass ring can be cast by a molder, then turned true by a machinist, then taken to a sheet-metal worker to be built into the gage. This method of construction places upon the owner final responsibility for the accuracy of the collector.

THE CRITERIA OF A COLD WINTER

By ALFRED J. HENRY

The need is often felt of criteria to briefly and precisely express the degree of abnormality of a season, more particularly the winter. Common usage employs the adjectives hard, severe, or mild and open, to distinguish between the two extremes usually experienced. Common usage, however, is notoriously inexact and different persons use the above-mentioned adjectives in a different sense.

The writer has sought to classify winters as a whole, meaning the usually recognized winter months of December, January, and February, according to the abnormalities of temperature which these months exhibit. He has also attempted, although unsuccessfully, to attach weights to the different winters based on the money loss suffered by transportation and agricultural interests as a direct result of adverse weather.

At present there is no organization under Government control through which a census could be made of the economic results of severe winter weather, and, moreover, difficulties arise in the exact delimitation of the areas that suffered economic loss. These and other conditions operate to restrict the useful criteria to those of a meteorological nature.

The chief meteorological criteria must of necessity be temperature and precipitation, of which the latter, in winter, is of secondary importance.

Temperature data may be utilized in several ways, for example, in order to determine the months of greatest cold, the number of days with minimum below an arbitrarily selected figure may be compiled; or, instead of using absolute minima, departures from the monthly means may be used. Any temperature data utilized must be arbitrarily selected with reference to the climate of the region, particularly the degree of continentality that obtains. Numerous trials have been made in order

to determine whether any particular phase of the temperature data is best adapted to indicate the degree of abnormality of the season. As a result of these trials it was found that the order of magnitude of the abnormality was practically the same whatever method was used; hence in the interest of simplicity the method of departures of the monthly means from normal has been selected. This method is, in short, as follows: If the monthly departures of December, January, and February be expressed by a+b+c, then the algebraic sum of these departures divided by 3 will give a value that may be considered as expressing with fair accuracy the temperature abnormality of the winter. A concrete illustration follows. Winter of 1924–25 at Washington, D. C., temperature departure of the three winter months, Dec. −0.2, Jan. −0.4; Feb. +7.8; sum, +7.2, which divided by 3 gives a departure for the winter of plus 2.4 F.

The abnormalities for five stations, San Francisco, Salt Lake City, Denver, St. Louis, and Washington, have been computed for each winter of the record from about 1871 to 1923. The individual seasonal departures may be arranged in a descending series from the coldest winter of record to those that may be classed as average or moderately cold. This has been done, although the table is not reproduced. It shows that extremes of cold weather are rarely, if ever, so widespread as to embrace the greater part of the area of continental United States, but rather the tendency is for the extreme cold to be localized in a relatively small area; hence the table does not answer the question, "What was the coldest winter in the United States as a whole during the last 50-odd years?" The magnitude of the temperature departure depends, of course, upon the continentality of the different parts of the area; for example, the northern boundary States of Montana, North Dakota, and Minnesota, being remote from the oceans and in close contact with regions to the northward having severe winters, show the greatest variations from the monthly means, and the magnitude of these variations diminishes with distance to the south and toward both the Atlantic and Pacific Oceans. There is, moreover, a tendency toward a reversal of the sense of the temperature departure between the Pacific slope States and the region east of the Rocky Mountains. The second coldest winter at San Francisco, 1889–90, was the warmest winter in the 50-odd years east of the Mississippi. There is also some indication of a west-to-east movement of great abnormalities, as, for example, the coldest winter at Salt Lake City, 1916–17, was followed by the very cold winter of 1917–18 east of the Mississippi. Other interesting comparisons are possible. The abnormalities of individual seasons for, say, 50 years also afford some basis of classification. Two tentative classifications, the first for the Pacific coast, the second for the interior, are presented below.

Classification of winters

	(a) Pacific	(b) Interior
Average winter, limits between	+0.5 and −0.5	+1.0 and −1.0.
Moderately warm	+0.6 and +1.5	+1.1 and +3.0.
Warm	+1.6 and +2.5	+3.1 and +5.0.
Very warm	+2.6 up	+5.1 up.
Moderately cold, limits between	−0.5 and −1.5	−1.1 and −3.0.
Cold	−1.6 and −2.5	−3.1 and −5.0.
Very cold	−2.6 up	−5.1 up.

An example of the classification of winters according to the limits above given is given in Table 1.

TABLE 1.—*Abnormal winters at San Francisco, Salt Lake City, Denver, St. Louis, and Washington, classed as average, moderately cold, cold, very cold, etc.*

	San Francisco		Salt Lake City		Denver		St. Louis		Washington	
	Years	Departures	Years	Departures	Years	Departures	Years	Departures	Years	Departures
Average	1891–92	±0.0	1919–20	−0.7	1879–80	−0.8	1914–15	−1.0	1882–83	−0.8
Moderately cold	1897–98	−1.2	1887–88	−1.5	1876–77	−2.7	1919–20	−3.0	1884–85	−2.6
Cold	1882–83	−1.7	1892–93	−3.7	1878–79	−4.0	1901–02	−4.3	1892–93	−3.5
Very cold	1909–10	−2.5	1916–17	−5.8	1898–99	−7.3	1917–18	−6.9	1904–5	−5.5
Moderately warm	1888–89	+1.3	1899–00	+1.4	1889–90	+2.3	1891–92	+2.3	1895–96	+1.8
Warm	1917–18	+1.8	1920–21	+3.1	1895–96	+4.5	1918–19	+5.2	1890–91	+3.2
Very warm	1876–77	+3.2	1906–07	+5.7	1906–07	+5.8	1889–90	+9.1	1889–90	+9.8

A REMARKABLE TWO-THEODOLITE PILOT-BALLOON SERIES

By WILLIAM C. HAINES

[U. S. Weather Bureau, Washington, D. C.]

An interesting series of two-theodolite pilot-balloon observations was made at the aerological station at Broken Arrow, Okla., on October 14, 1924. The series consists of five soundings, all of which reached altitudes of 11,000 to 14,000 meters (roughly 7 to 9 miles) above the surface. Wind velocity and direction graphs of four of the five soundings are reproduced in Figure 1. The observations were made at 7:03a, 10:05a, 1:23p, 3:02p, and 4:57p. The graph of the observation taken at 4:57p, is omitted from the accompanying figure, but it is similar to the other four in all essential characteristics. Since all of these observations were made with two theodolites, their accuracy can not be questioned.

The following are some of the interesting features of the observations: Light winds averaging only 4 or 5 meters per second (about 10 miles per hour) prevailed up to approximately 7,000 meters. Above this altitude the wind increased very rapidly, attaining velocities as great as 50 meters per second (112 miles per hour). Apparently above 13,000 meters the velocity decreased as shown by the highest graph. The wind direction above 4,000 or 5,000 meters was from west to northwest and remained practically constant throughout the day. Below this altitude the direction was variable, finally shifting to southeast from the surface up to 3,000 meters in the late afternoon.

Another interesting feature of the series is the persistency throughout the day of the small irregularities in wind velocity. Note the increases in velocity marked "a" and "b," which are evident in all four graphs. They are also just as pronounced in the fifth graph, which is not reproduced.

The weather map on the morning of the 14th showed a flat HIGH central over the upper Mississippi Valley, with a weak trough of low pressure extending north and south across the country just east of the Rocky Mountains. The high-pressure area moved eastward and at 8 p. m. was central over the Upper Lake region.

It is probable that all of these soundings penetrated the stratosphere, although there is nothing to bear out this statement except the height attained and the decrease in velocity above 13,000 meters. High velocities are not always present at great altitudes. Many soundings that reach altitudes from 10,000 to 15,000 meters show comparatively low wind velocities from the surface up. Very often the wind velocity at high levels appears to bear no relation to the surface condition shown by the current weather map.

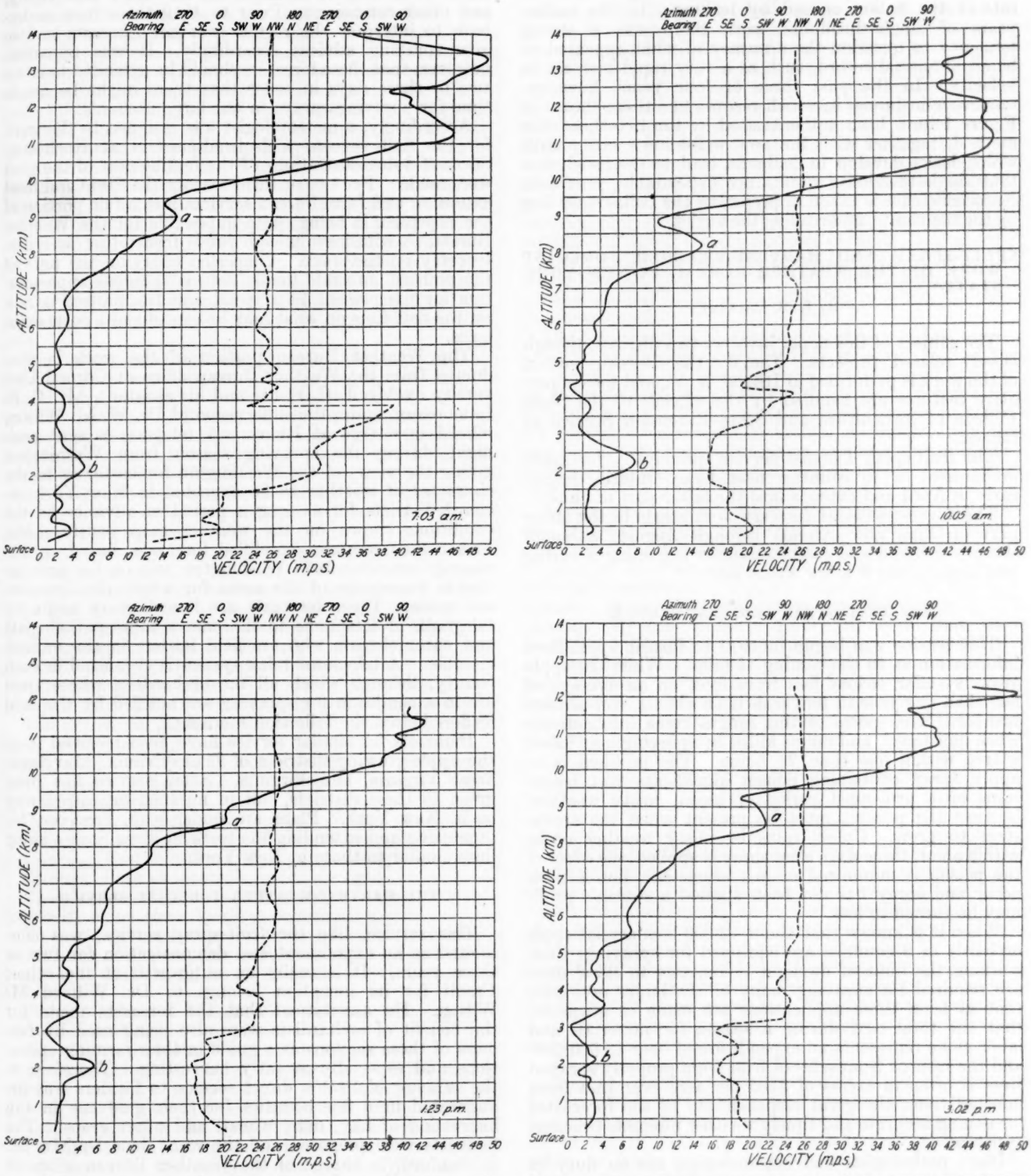


FIG. 1.—Wind direction and velocity, (m. p. s.,) in the free air at Broken Arrow, Okla., on October 14, 1924. Broken lines represent direction, with legend at top, and solid lines, velocity, with legend at bottom. Altitude in kilometers is indicated in the margin. The time of the observations on which the curves are based is indicated on the graph.

In single-theodolite work, when a very rapid increase in velocity is encountered, the question arises as to its reality, since it may be explained by faulty ascensional rate of the ballon caused by leaking. In the earlier years of single-theodolite work there was a strong tendency to question the accuracy of what appeared to be an abnormal record, such as a very rapid increase in velocity. In the past three or four years, however, numerous instances in which records like those shown in Figure 1 have been authenticated by the two-theodolite method, together with the now well-known rarity with which leaks develop in balloons, lead to the conclusion that single-theodolite results are dependable, providing reasonable care is taken in preparing the balloon, setting up the theodolite, and reading the angles.

FRUIT-SPRAY AND HARVEST-WEATHER FORECAST WORK OF THE WEATHER BUREAU IN NEW YORK STATE[1]

By E. B. CALVERT

The subject of this paper involves two distinct, though closely related, projects. The Weather Bureau portion of the work is performed at Ithaca, N. Y., and the cooperative features are handled by the officials of the State College of Agriculture and State Extension Service at Ithaca.

The fruit-spray forecast service, principally for apple orchardists in 10 counties near Lake Ontario, begins early in April and extends into the latter part of June.

The harvest-weather forecast work starts in the latter part of June and extends through August, although there is demand and justification for beginning it earlier and terminating it a few weeks later.

THE FRUIT-SPRAY FORECAST SERVICE

This service was begun in 1919 to furnish specialized information as to the coming of rains. While the apple growers suffer serious loss from frost on an average of less than one year in ten, scab is an almost ever-present menace. The spores of this fungus come into activity when moistened, and unless killed by spraying may infect a tree within less than 24 hours. The problem is to apply spray containing poison ingredients just before rains or a prolonged period of moist, misty weather, because the poisons must be present when the spores start to grow. Unless rains or misty weather occur within about three days after spray is applied, the effect of the poison is minimized or lost altogether, but if rains occur and spray has not been applied a season's profit may be turned to loss.

When it is known that about 12,000 commercial apple orchards in 9 counties are equipped for spraying; that, working the limit of daylight hours, two to three days are required for spraying many of the larger orchards; that at least three applications are made in a season; that the total cost during a season for materials and labor alone represents an expenditure of over $3,500,000; and the returns from sales of fruit from properly sprayed trees is often in excess of $100 per acre over that from infected trees, the great responsibility of the forecaster for issuing accurate and timely weather forecasts becomes apparent.

Plant pathologists and entomologists are on duty in nearly all the apple-growing counties during the spraying season for the purpose of watching swelling, budding, and blooming developments and determing when the various orchards are in the proper stages for spraying, This varies according to nearness to the lake, topography, and other conditions. Prior to 1919 these men undertook to interpret the regular weather forecasts and to give spraying advices accordingly. It was apparent, however, that these forecasts should be extended to cover two or three days in order that there might be ample time for applying sprays in the large orchards.

Accordingly, a meteorologist was assigned to the work for the first season, with headquarters at Rochester. Successful demonstrations of the feasibleness of the plan were made. For two or three seasons the State and local extension and farm bureau services met a fair portion of the expenses, it being quite impossible for the Weather Bureau to withdraw enough funds from other activities to carry on the work. Concerted effort on the part of the orchard interests finally secured a small appropriation for the present fiscal year, and the project is now for the first time on what may be considered a permanent basis.

The Weather Bureau portion of the work is conducted from the Weather Bureau office at Cornell University by Mr. J. C. Fisher and his assistant, Mr. C. E. Lamoreaux, under the supervision of Dr. W. M. Wilson, official in charge at Ithaca. A telegram is sent each night during the spraying season from Washington giving the views of the Washington forecaster as to the character of weather to be expected in New York orchard districts for as long a period in advance as the conditions shown on the weather map justify. Mr. Fisher then prepares amplified forecasts, based on the message received from Washington and on his own intimate knowledge of the areas for which the forecasts are made. These forecasts are issued every night by telegraph or telephone to the one or more pathologists and entomologists who are field leaders in the various counties. A telephone relay system is organized in each county, through which all the orchardists whose trees are in a condition for spraying are notified by the field leaders before the following morning.

Demands for similar service have been received from the apple-growing districts of Pennsylvania, Maryland, West Virginia, and Virginia. Some service has been given to these districts, but in no such organized way as in New York. Plans are under way, however, for organizing and extending the work in these States along lines similar to those in New York.

THE HARVEST-WEATHER FORECAST SERVICE

This service, like the fruit-spray service, was conducted as an experiment and demonstration for two or three years. It is really an outgrowth of the other. Credit for its inception belongs to Dr. Wilford M. Wilson. He ascertained that the forecasts made for the benefit of orchardists were also being used by farmers of those sections as a guide in their farming operations and especially in early harvesting. Therefore in the summer of 1921 a direct service to farmers was inaugurated in a few counties for their guidance in the harvesting of hay, oats, wheat, and other crops. The forecasts were prepared and the work done by Mr. M. R. Sanford, in charge of the Weather Bureau office at Syracuse. He performed all the duties connected therewith until this last season, when for administrative reasons it was transferred to Ithaca. It is due largely to Mr. Sanford's energy and ability that the demonstration was so highly successful.

[1] (Read at the meeting of the American Meteorological Society, Jan. 2, 1925, Washington, D. C. The following text is condensed from the original.—*B. M. V.*)

The work was conducted in cooperation with the State Agricultural and Home Bureau officials and county agents, and a part of the expenses were paid by these agencies. The response to the first season's efforts was not only encouraging but surprising, the farmers very evidently appreciating the organization of the service for their benefit. This first season of demonstration showed that the project could not be abandoned. Three years of successful forecast service and the energetic efforts of the people of New York engaged in agricultural extension work had their combined effect, and in the appropriations for the Weather Bureau for the current fiscal year a little less than $10,000 was made available for the harvest-weather and fruit-spray forecasts projects together. The appropriations did not become effective until July 1, 1924, too late to utilize any of it for the fruit-spray work; but in the meantime Doctor Wilson, Mr. Fisher, and the remainder of the force at the Ithaca office worked out a splendid program and organization which were ready to go into action on that date.

The harvest-weather forecast work this year was confined to July and August. It was recognized that it should have been extended into September, but since it was the first year of the expanded and organized service caution in respect to appropriations and expenditures had to be exercised. As a result the bureau kept well within the available funds. Therefore next year, provided telegraph rates remain the same (which now seems very doubtful), additional counties will come within the provisions for service.

The project involves many unique features and in a way marks an epoch in the work of the Weather Bureau in service directly for the benefit of farmers. It is perhaps not so spectacular as the fruit-spray service, but from the standpoint of the number of individuals benefited, aggregate value of the crops affected, and total economic returns in prevention of losses, it far transcends the fruit-spray activities. Therefore, the phrasing and interpretation of the forecasts will be given in some detail.

The system of phrasing the forecasts was designed to meet practical problems in a practical way and is employed invariably and consistently. It corresponds fairly closely to that used in the regular forecasts issued for the general public:

Fair, partly cloudy, or *cloudy* mean: No rain expected.
Rain means: General rain of several hours duration.
Clearing: End of rainy spell is approaching.
Showers: Rain at intervals, probably light.
Thunderstorms: Local thunderstorms; forecaster unable to specify exact time, locality, or intensity.

To the foregoing terms, words are added to indicate the probability of the weather occurring as forecast; that is, the weight that should be given to the day's forecast, as follows:

Strongly indicated: Weight 90 to 100 per cent.
Indicated: Weight 70 to 80 per cent.
Unsettled or *probable:* Weight 50 to 60 per cent.

An example of an actual forecast is: "Good drying weather strongly indicated for Wednesday; also indicated for Thursday; Friday unsettled, probably rain."

Cards explaining the terms used in the forecasts and the weight to be applied were distributed to practically every farmer in the counties concerned. With a forecast such as given in the above-quoted example a farmer could plan his work with reasonable assurance of fine weather for one day and probably two, but must take into account the uncertainty of the third day, for which there was more than an even chance for rain.

During the past season 35 counties were served, representing practically all of the important agricultural sections of the State. Responsible persons having contact with the rural telephone lines were selected to act as distributors of forecasts. They in turn secured the names and addresses of every farmer having telephone service. A notice regarding the service, the card explaining the form and terms of the forecast, and a pamphlet of an educational nature giving elementary facts regarding weather forecasting, the movement of storms, etc., were sent to each of these farmers.

A message, usually telegraphic, but occasionally by telephone, containing forecasts applicable to his section, was sent daily, Sundays excepted, to each distributor, reaching him as a rule before 11 a. m. In most cases the farmers called the distributors between 11 a. m. and 1 p. m., but in some instances the distributors called the subscribers on each line by a significant ring, so that all who desired to do so could listen in while the forecasts were read.

The total number of distributors employed last season was 258, an average of 8 or 9 to a county. In 5 of the 35 counties the distribution was accomplished entirely by radio through the station of the General Electric Co. at Schenectady. The total number of farmers to whom the forecasts were made available, calculated from the number of telephone subscribers and not including the counties covered by radio distribution, was about 24,000.

At the end of the season a questionnaire card was sent to a considerable number of farmers for the purpose of ascertaining the extent to which the service was used, the general accuracy of the forecasts, and soliciting questions and comments as a guide in preparing for the next season's work. Returns were received from 2,218 persons. Of this number 1,907 indicated that they used the forecasts in their harvesting operations and 311 said they did not, but of this latter class 198 said they believed the service would be of value to them and that they intended to try it next year. Only 29 expressed the opinion that it was of no use to them and that they did not want it.

THE CLIMATE OF TRINIDAD, B. W. I.[1]

By PRESTON E. JAMES
[University of Michigan]

The island of Trinidad, British West Indies, is located about 10° north of the Equator, off the mouth of the Orinoco River. Along the northern coast of the island runs a mountain range, its highest peaks reaching elevations a little over 3,000 feet (900 meters). South of this there are two belts of moderate relief (fig. 1), trending roughly northeast-southwest. Between these belts there are two areas of lower relief, partly a dissected plain, and partly flatlands and swamps. The climate of this island may be classified as a rainy, low-latitude climate, modified by an insular position.

Temperature.—Complete, long-period weather observations are available only for the St. Clair Experiment Station (Port of Spain). This station is located 66.7 feet (20.3 meters) above sea level, on the lee side of the island (fig. 1). Its records go back to 1862, and may be taken as fairly typical of the whole island as regards temperature conditions.

The average annual temperature for the period 1907–1916 was 77.3° F. (25.2° C.). The annual range is char-

[1] Read before the American Meteorological Society, Washington, D. C., Jan 2, 1925. Data from Trinidad official statistics and from observation in the field.

acteristically equatorial, being only 3.2° F. (1.8° C.). It varies from 75.6° F. (24.2° C.) in January, to 78.8° F. (26° C.) in May. The average daily range is 16.7° F. (9.3° C.). On clear days and in the dry season the diurnal ranges are greater than on cloudy days and in the rainy season. February, the driest month, has the highest average daily range, 19.2° F. (10.1° C.); while August, the rainiest month, has the lowest, 14.4° F. (8.0° C.). The highest temperature recorded is 101° F. (38° C.) in the month of September, and the lowest 57° F. (14° C.) in January. Since there is in Trinidad very little land high enough to reach the *Tierra Templada*, these data are essentially typical of the whole island. Slightly greater daily ranges are undoubtedly found in the deep, basinlike valleys of the Northern Range, but the differences would not be critical.

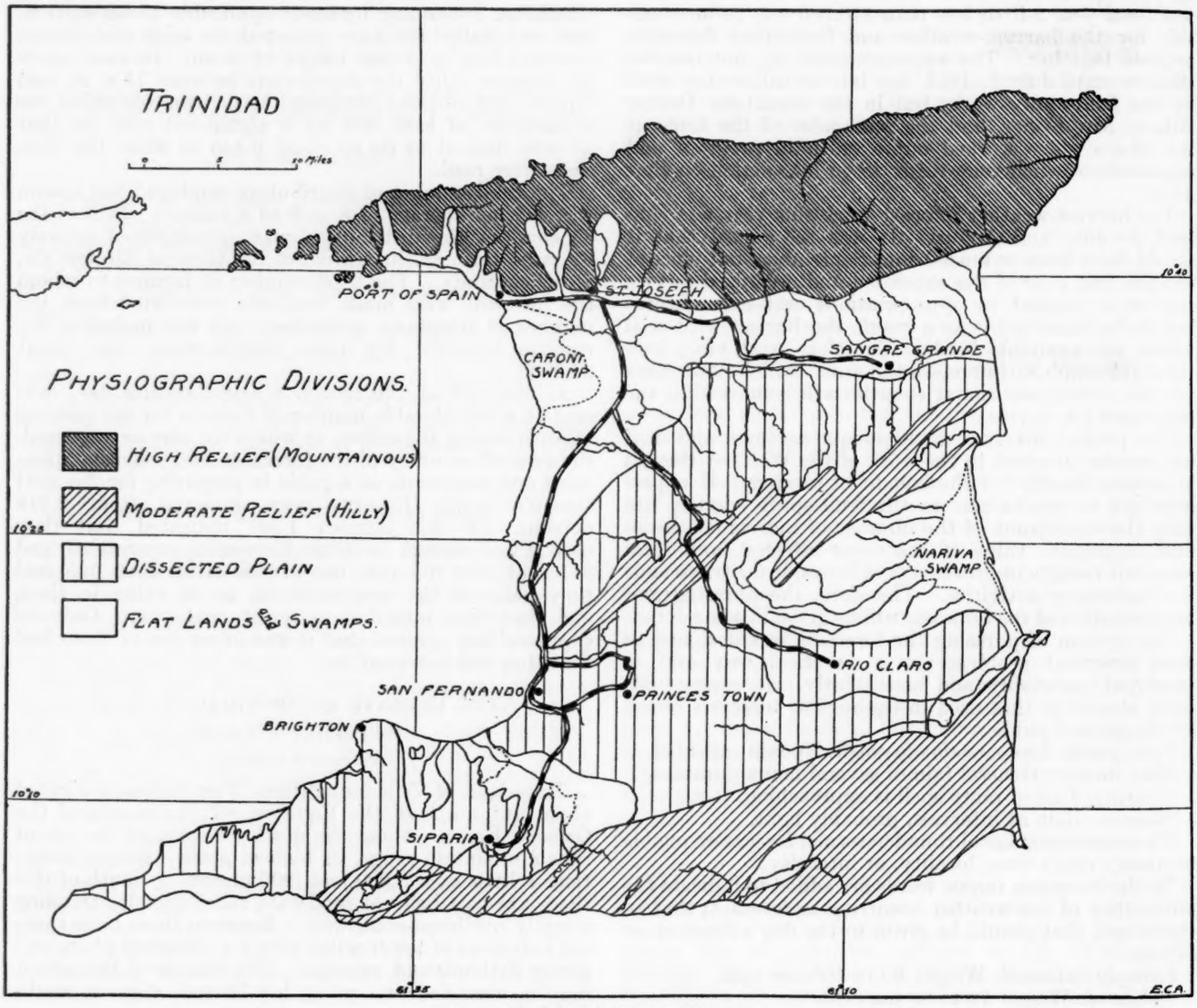


FIG. 1.—Physiographic divisions of Trinidad.

Rainfall.—The variety of the surface features of Trinidad is reflected in the marked differences in the amount of rainfall received at various stations (fig. 2). In the northeastern part of the Northern Range a fall of over 150 inches (3,800 millimeters) has been unofficially but competently recorded. Extending southward from the Northern Range about three-fourths of the distance to the southern coast, and lying inland from the east coast about 5 miles (8 kilometers), there is a belt of over 100 inches (2,500 millimeters) of rainfall. Since the island lies within the range of the belt of equatorial rains, and since the mountain ranges run parallel to the direction of the prevailing winds, there is no arid or semiarid lee coast such as is commonly found on islands in the trade wind belts. The western side of Trinidad however, receives less than 60 inches (1,524 millimeters) of rainfall, and on the westernmost islands of the Bocas (between Trinidad and Venezuela) the fall is less than 50 inches (1,270 millimeters). With the high evaporation at these latitudes, and possibly unfavorable soil or drainage conditions, this rainfall is sufficient only to support a marked xerophytic vegetation on these Bocas islands.

The rain comes in the form of convectional showers. usually accompanied by lightning and thunder, and followed by periods of brilliant sunshine. The showers form in the belt of over 100 inches and drift westward over the island with diminishing violence, usually

following the axes of the mountain or hilly belts, where the up-valley winds supplement the convectional currents The larger amount of rainfall received in these areas of rough surface can be seen on the rainfall map (fig. 2).

The rainy part of the year comes later in Trinidad than it does farther south along the Guiana and Amazon coast.[2] There is no month of the year in any part of Trinidad which is rainless; but the rains are distributed in a marked rainy season from June to December and a marked dry season from January to May. All of the

TABLE 1.—*Average monthly rainfall by seasons at selected stations (in inches)*

Station	Dry season (January–May)	Rainy season (June–December)
St. Clair	2.2	7.4
Grande Riviere	4.7	11.3
Couva	1.6	6.5
Siparia	2.8	8.2

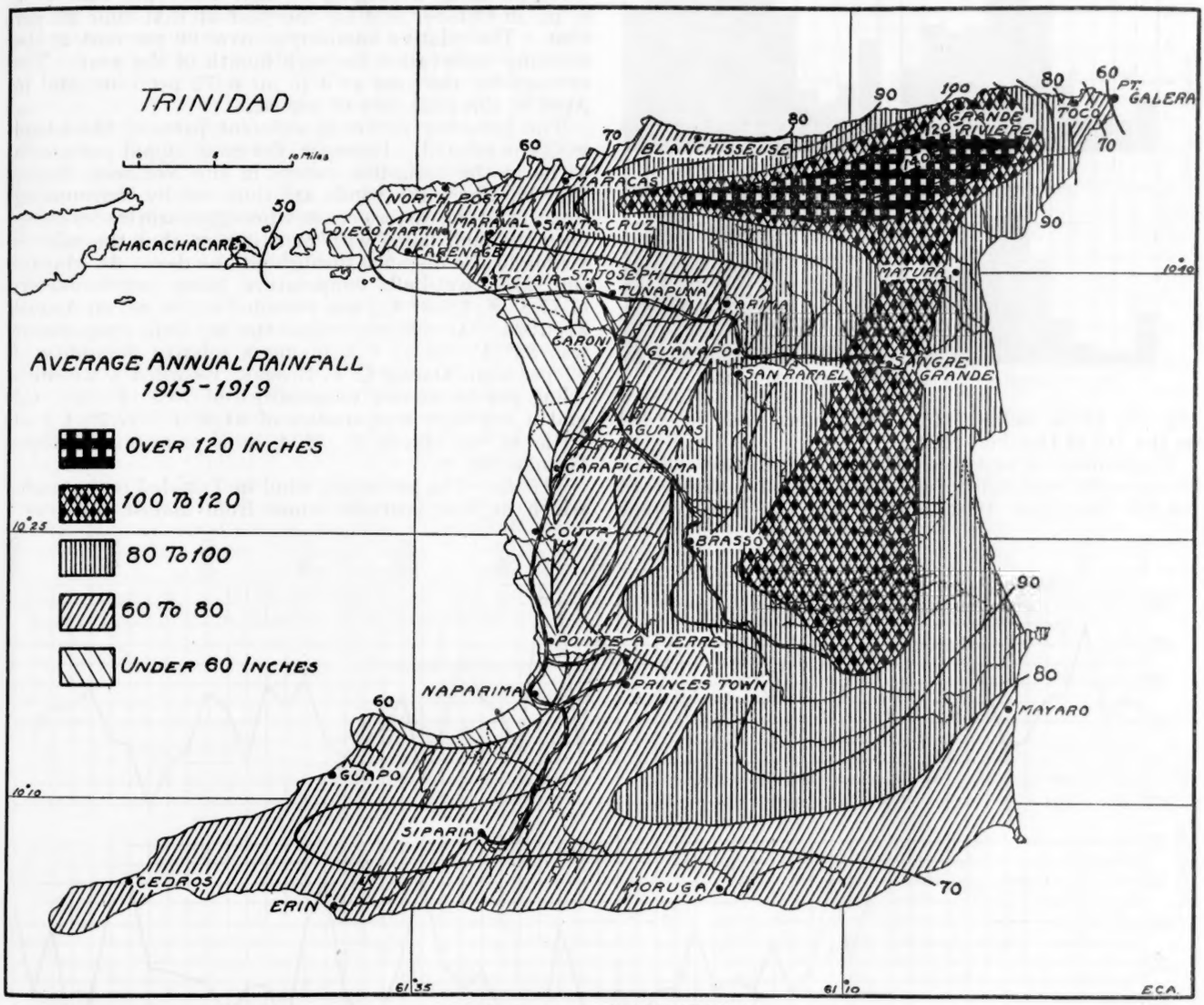


FIG. 2.—Average annual rainfall of Trinidad.

Trinidad stations show a tendency to a double maximum during the rainy season, the first in July–August and the second in November. Between these, September appears regularly as a month of less rain, although less strongly marked in some parts of the island than in others. This characteristic distribution may be seen on the charts for St. Clair, Grande Riviere, Couva, and Siparia (fig. 3). (For the location of these stations see Figure 2.) Table 1 gives the average monthly rainfall for the dry season and the rainy season at these stations.

At most of the stations the largest amount of rainfall comes in July or August. St. Clair, for example, has a maximum of 9.7 inches (246.4 millimeters) in August. However, the stations along the exposed windward coasts, as Grande Riviere, receive as much rain in November as in the early maximum. At Grande Riviere 13.9 inches (353.1 millimeters) is the average for July, and 14 inches (355.6 millimeters) the average for November. The driest months are February or March. At St. Clair the driest month, February, receives 1.5 inches (38.1 millimeters); and Grande Riviere in March receives 2.6 inches (66 millimeters). At St.

[2] W. G. Reed. South American Rainfall Types. Quart. Journ. of the Royal Met. Soc. Vol. 34, January, 1910.

Clair the largest amount of rainfall recorded for any 24-hour period was 5.9 inches (149.9 millimeters) in October. At the constabulary station at Sans Souci, located a little east of Grande Riviere on the north coast

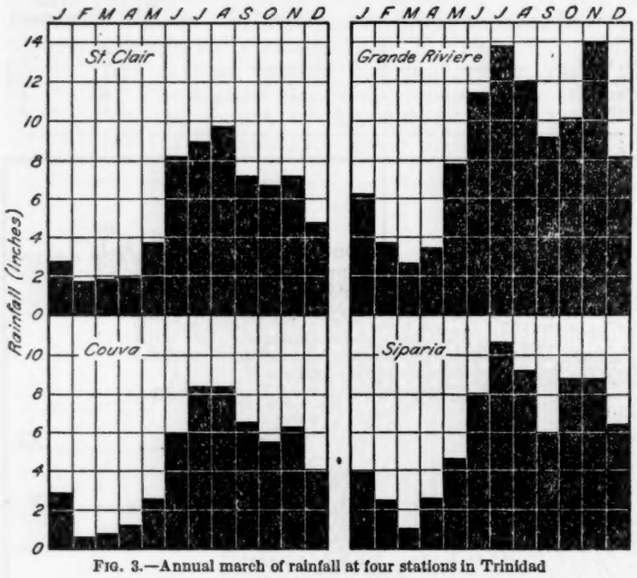


FIG. 3.—Annual march of rainfall at four stations in Trinidad

(fig. 2), 17.54 inches (445.5 millimeters) was recorded on the 7th of October, 1921.

The amount of rain received from year to year shows a considerable variability, as is indicated by the record for St. Clair from 1862 to 1919 (fig. 7). The average annual rainfall for this period is 64.28 inches (1,633 millimeters). The chart shows that up to about 1893 the rainfall on the whole was increasing in amount, but that from 1893 to 1913 the trend was a steady decrease. This diminishing rainfall since 1893 has been attributed by many people in Trinidad to the cutting off of the forests. That this trend is, on the contrary, related to world-wide conditions is suggested by a comparison with the rainfall for Corrientes, Argentina.[3] At this station the changes from one year to the next in 60 per cent of the cases are opposite. Plainly these fluctuations are not the result of any purely local influences.

Humidity.—Cloudiness and humidity reach a maximum in August, September, and October. At Port of Spain the average relative humidity (combining the observations for 7 a. m. and 3 p. m.) is 80 per cent. The highest relative humidities are, as usual, found in the early morning, averaging as high as 96 per cent at 7 a. m. in October and for the year at that time 93 per cent. The relative humidity is over 90 per cent at the morning observation for each month of the year. The average for the year at 3 p. m. is 72 per cent, and in April at this time only 66 per cent.

The humidity differs in different parts of the island with the rainfall. However, the most humid parts seem to be in the basin-like valleys in the Northern Range (fig. 1), where the winds are shut out by surrounding slopes, and the eastern coast, where the warm trades sweep onto the land laden with moisture, so that the mist is visible in the distance throughout the day. At Mayaro (fig. 2) a wet-bulb temperature (sling psychrometer) of 77.5° F. (25.3° C.) was recorded at 8 a. m. on August 31, 1924. At this same time the dry-bulb temperature was 82° F. (27.8° C.), giving a relative humidity of 82 per cent. Doctor C. F. Brooks[4] recorded a wet-bulb (sling psychrometer) temperature of 75.2° F. (24° C.) and a dry-bulb temperature of 81.8° F. (27.7° C.) at 10 a. m. on March 13, 1924, at a point near Sangre Grande (fig. 2).

Winds.—The prevailing wind in Trinidad is the trade, which at this latitude comes from almost due east. The strength of the wind is notably greater during the period of low sun and the dry season than during the rainy season. For Port of Spain the average wind velocity for the period 1919–1922 was 6.26 miles per hour. The average for the dry season was 7.08 and for

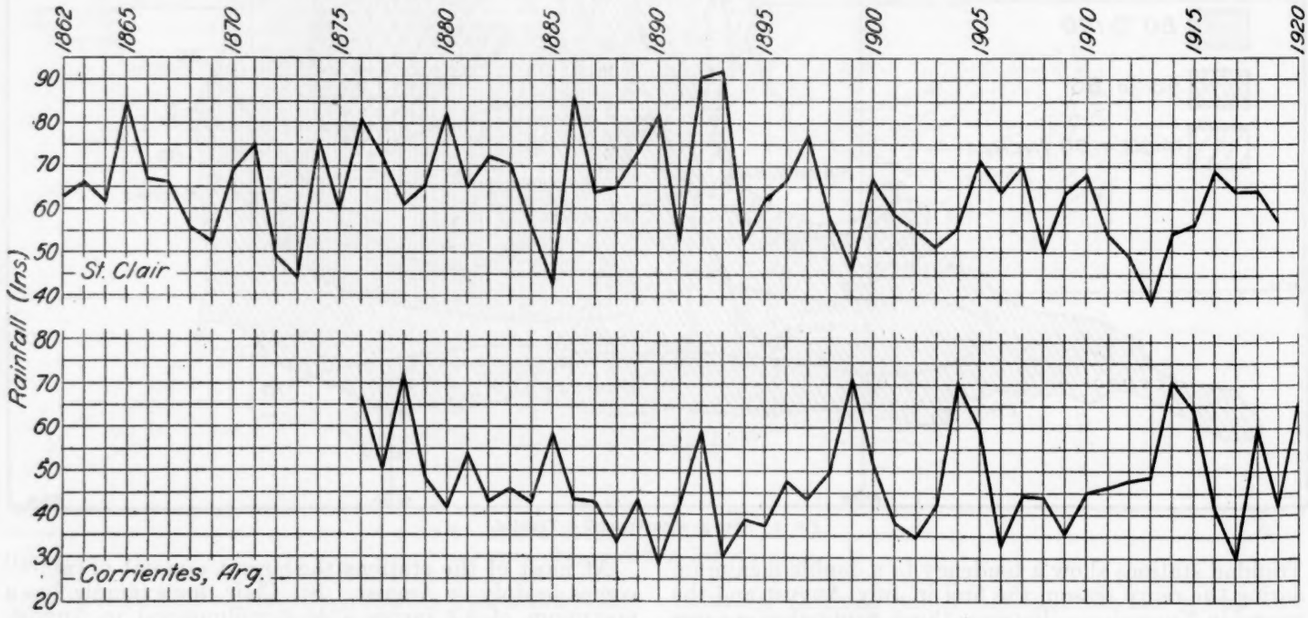


FIG. 4.—Annual variations in rainfall at St. Clair, Trinidad, and Corrientes, Argentina

[3] Data furnished by Dr. H. H. Clayton.
[4] Personal conference with Dr. Charles F. Brooks.

the rainy season 5.70. Furthermore, of all the days observed during this period, 86 per cent had at least a five-minute period during which the wind velocity was 25 miles (40 kilometers) per hour or over. This degree of windiness was observed 94 per cent of the days in the dry season and 83 per cent of the days in the rainy season.

During the dry season the wind reaches the westernmost parts of the island with characteristic trade-wind force, but during the rainy season it is felt for only a few miles inland from the eastern coast. Sometimes at this period of the year it dies down sufficiently at night for the development of a land breeze on the eastern coast in the opposite direction to the prevailing wind. Such a shift of wind was observed at Mayaro (fig. 2) during the night of August 30–31, 1924. While the land breeze was blowing, mosquitoes in great numbers from the swamps back of the coast (fig. 1) were blown out over the coastal villages. The large amount of cacao grown on Trinidad requires some form of protection from the strong trades. These winds do not, as is often stated, break off the cacao pods, but rather they increase evaporation and decrease the [relative] humidity, a condition which is fatal to cacao. An interesting feature of the wind protection is the relatively narrow belt of trees which is sufficient to shut out the winds. Cacao plantations near Sangre Grande and along the northeastern coast are planted very close to the exposed shore. In a coconut plantation along the immediate coast near Mayaro no wind could be felt about 200 yards (180 meters) from the beach at a time when a strong on-shore trade was blowing.

Weather types.—The weather types at Port of Spain may be taken as typical of at least the drier western part of the island. The usual combinations of temperature, rainfall, and wind velocity could not be made owing to the lack of simultaneous records. The rainfall and temperature data cover the period from 1915–1919, but the wind data, as previously mentioned, are from 1919–1922. However, a large percentage of the days are "windy," so that the absence of [a long record of] this element is less serious than might be the case in a less uniform climate.

The following combinations of temperature and rainfall were made:

Temperature (daily mean from maximum and minimum).
- Warm: Under 68° F. (20° C.).
- Hot: 68° F. to 80° F. (20° to 26° C.).
- Very hot: Over 80° F. (26° C.).

Rainfall (daily total).
- Fair: Less than 0.01 inch (0.25 millimeter).
- Rainy: 0.01 to 0.99 inch (0.25 to 25.15 millimeters).
- Very rainy: Over 0.99 inch (25.15 millimeters).

These were combined into eight weather types as follows: Hot and fair, hot and rainy, hot and very rainy, very hot and fair, very hot and rainy, very hot and very rainy, warm and rainy, warm and very rainy. Warm and fair did not occur at all during the period studied. The percentage of the total number of observations on which each of these types occurred is shown in Table 2.

The type hot and fair was the most common one, taking 48 per cent of the time. Hot and rainy occurred 41 per cent of the time, while the other types were much less common. The uniformity of temperature, characteristic of the rainy low latitudes, is revealed by this repetition of daily means between 68° F. (20° C.) and 80° F. (26° C.). Very hot days were more common during the dry season than during the rainy season, the percentages being 7.4 and 6.7, respectively, while warm days occurred very seldom, and never during the dry season.

The percentage of rainy and fair days is illuminating in relation to the terms rainy and dry seasons. During the dry season 69 per cent of the days were fair, 30.4 per cent were rainy, and 0.6 per cent were very rainy. During the rainy season, 40.7 per cent of the days were fair, 53 per cent were rainy, and 6.3 per cent were very rainy. These figures are probably essentially characteristic of stations in this type of climate.

TABLE 2.—*Occurrence of weather types at Port of Spain*

(Figures are percentages of total days of observation)

Weather types	January	February	March	April	May	June	July	August	September	October	November	December	Dry	Rainy	Year
Hot and fair	62.5	69.5	68.5	61.4	54.3	38.7	32.3	30.3	37.3	37.4	37.3	50.3	63.1	37.7	48.16
Hot and rainy	36.2	29.1	28.3	18.0	32.2	51.3	56.7	52.3	50.6	43.2	51.4	47.1	28.9	50.4	41.49
Hot and very rainy	1.3	0	0	.6	1.3	6.0	7.1	5.8	6.7	7.8	6.0	2.6	.6	5.9	3.78
Very hot and fair	0	1.4	2.6	18.0	7.7	3.3	.6	3.9	3.4	8.4	1.3	0	5.9	3.0	4.21
Very hot and rainy	0	0	.6	2.0	4.5	.7	.7	7.7	2.0	3.2	3.3	0	1.5	2.5	2.08
Very hot and very rainy	0	0	0	0	0	0	1.3	0	0	0	0	0	0	.2	.11
Warm and rainy	0	0	0	0	0	0	.7	0	0	0	0	0	0	.1	.06
Warm and very rainy	0	0	0	0	0	0	.6	0	0	0	.7	0	0	.2	.11
Fair	62.5	70.9	71.1	79.4	62.0	42.0	32.9	34.2	40.7	45.8	48.6	50.3	69.0	40.7	52.37
Rainy	36.2	29.1	39.9	20.0	36.7	52.0	58.1	60.0	52.6	46.4	54.7	47.1	30.4	53.0	43.63
Very rainy	1.3	0	0	.6	1.3	6.0	9.0	5.8	6.7	7.8	6.7	2.6	.6	6.3	4.00
Hot	100.0	98.6	97.8	80.0	87.8	96.0	96.1	88.4	94.6	88.4	94.7	100.0	92.6	94.0	93.43
Very hot	0	1.4	3.2	20.0	12.2	4.0	2.6	11.6	5.4	11.6	4.6	0	7.4	6.7	6.40
Warm	0	0	0	0	0	0	.3	0	0	0	.7	0	0	.3	.17

NOTES, ABSTRACTS AND REVIEWS

RAINFALL CORRELATIONS IN TRINIDAD, BRITISH WEST INDIES

(Abstracted from Nature, No. 2884, 115: Feb. 7, 1925, pp. 192-3)

Preliminary investigation by W. R. Dunlop has established the fact that annual variations in the yields of certain crops in Trinidad, the deviations in which sometimes amount to 100 per cent or more from a five-year moving average, are primarily due to fluctuations in rainfall. For La Vega estate (cacao) the very high negative correlation -0.95 ± 0.10, was found between May-June rainfall and the yield of the subsequent crop. For May rainfall alone (six months earlier than the harvest) the correlation was -0.85 ± 0.15. Hence, contrary to local opinion, smaller yields appear to be due, at least partly, to too much rain rather than to too little.

The point is emphasized that statistical analysis of weather-and-crop relations for the Tropics is assuming prime importance as contrasted to purely descriptive treatment, this being especially true from the point of view of economic geography. Reference is made to the work on climatic factors and the cane crop for Mauritius by A. Walter, to M. Koenig's investigations in the same colony, and to those of T. A. Tengwall and C. E. van de Zyl in Java, where they found a positive correlation between sugar yield and the October-November rainfall.

In Trinidad variations of rainfall seem intimately to affect the whole economic activity. Business done in the shops fluctuates in amount not only in response to the current rainfall but to the previous season's rainfall through changes in the purchasing power of the people.—*B. M. V.*

THE SOLAR-CONSTANT AND THE FORECASTING OF TERRESTRIAL WEATHER

While continued critical investigations conducted by the Weather Bureau[1] appear to furnish convincing evidence that the magnitudes of the alleged changes in value of the solar-constant are, if the changes exist at all, well within the magnitudes of the uneliminated errors of observation, and therefore unknowable, and certainly not a satisfactory basis for forecasting the weather, nevertheless, the Bureau is glad to present the following extracts from the 1924 Annual Report of the Astrophysical Observatory of the Smithsonian Institution, indicating the present status of, and progress being made in, these interesting measurements.

As in previous years, the variation of the sun has been the main concern. The generosity of Mr. John A. Roebling enabled arrangements to be made for daily telegrams form our two solar radiation stations. This service was begun September 13, 1923. The results obtained in Chile are cabled in code, so that the weighted mean solar-constant, the date and hour of observation, and its grade are all included in two words. Messages arrive at Washington from both stations within 24 hours of the actual measurements, and generally represent mean results of five independent determinations at each station. Arrangements have been made (also owing to Mr. Roebling's interest and generosity) to test the value of the solar measurements for forecasting according to the methods of Mr. H. H. Clayton. For this purpose Mr. Clayton * * * receives before noon daily from the Smithsonian Institution the weighted mean of the solar-constant values observed in Arizona and Chile on the preceding day. He makes his forecasts for 3, 4, 5, and 27 days in advance, and mails them to the Institution on the same afternoon. Thus we receive the forecasts sufficiently long before their maturity to make a very real and searching test of their validity.

These forecasts for definite days relate to the mean temperature of New York City, and are later on compared with the observed temperatures and analyzed by several purely mathematical methods quite independently of any bias of the computer. The official weather services of the various countries do not, of course, make predictions parallel to these, except in Argentina, where such forecasts are made by similar methods to Clayton's. Hence it is impossible to know at present how much gain, if any, Mr. Clayton's solar forecasts show over the present official methods. That they do show some prevision of the event, even to five days after the solar observations, is certain.

Hitherto, however, the 27-day detailed forecasts have shown no correlation with the New York temperatures. This is not at all surprising. Indeed, all such forecasts have to contend against great odds. For we recall that the march of temperature often goes quickly from crest to trough, so that even if a true forecast could be made, and it should be no more than 12 or 24 hours off in point of time, there would be large divergences between the prediction and the event. With the unyielding mathematical methods of verification this would greatly diminish the correlation found.

A fairer test for very long-range forecasts is found in general statements as to the expected departure from mean normal temperatures for coming months. These Mr. Clayton has furnished from 15 to 30 days before the beginning of each month from December, 1923, to the present time. He also furnishes similar predictions about the approaching weeks furnished three days before the beginning of the week in question. With few exceptions, these broader,prognostications have been fairly verified.

On the whole, therefore, although the results are as yet far from being entirely satisfying, these experimental forecasts of Mr. Clayton's are promising enough to warrant further trial. New methods are continually being devised and tried in making them. Mr. Roebling has generously arranged to continue them until June 30, 1925. As the work is purely experimental, no detailed publication of it will be made at present.

Naturally, if the forecasts made by Mr. Clayton really represent solar changes, he can not succeed unless good solar measurements are supplied. As soon as we began to receive daily telegrams from both stations occasional fairly wide disagreements of individual days commanded attention. We felt it necessary, in studying the causes of such disagreements, to revise again entirely the systems of little corrections to solar-constant values which have to be made to allow for the haziness and humidity of our atmosphere. This revision could be made with more advantage because much additional data had meanwhile accumulated.

* * * A new method of determining these corrections hsa been devised by the Director and Mr. Fowle, which eliminates satisfactorily the influence of the solar changes which have occurred. Hitherto this matter of solar change superposed upon the small terrestrial sources of error which we desire to eliminate has been very embarrassing. Of course, if one could wait many years before proceeding to evaluate the terrestrial effects, the solar changes, being independent or but loosely connected with local terrestrial ones, would be eliminated in the mean of a mass of observations. We can, indeed, after several years more of observing, finally proceed in this way. But, wishing to make immediate use of our results, a new method of procedure has fortunately occurred to us which permits us to avoid the interference of solar changes altogether. The details will be published soon.

As both to us and to the Chief of the Weather Bureau it seemed unwise to publish preliminary values of the solar constant which later on would have to be corrected, we have discontinued the frequent publications of them in the MONTHLY WEATHER REVIEW which we have been accustomed to make for several years past. After we come to a fully satisfactory basis of systematic atmospheric corrections, these publications may be resumed.

Of the two solar-radiation stations, Montezuma, Chile, has proved far more suitable to the purpose than Harqua Hala, Ariz. It seems probable that a place somewhat farther west and decidedly higher would be preferable to Mount Harqua Hala. Violent storms occur there in various months of the year, and the summer months in particular have proved very unsatisfactory. If financial means were available it would be highly desirable to remove the station to another site, and, indeed, a better one is already selected which would present many advantages. The cost of removal would be about $7,000.

The systematic revision of results in the hands of Mr. Fowle and Mrs. Bond has led to much improvement, as shown by the close accord of daily solar-constant values at the two stations. For the period September, 1922, to March, 1924, the average daily

[1] See 2 papers by Marvin, Charles F.: Forecasting the Weather on Apparent Short-Period Solar Variations.
Mo. Weather Rev. March, 1920, 48: 149-150.
Solar Radiation Intensities and Terrestrial Weather.
Mo. Weather Rev. April, 1923, 51: 186-188.
The data published in Smithsonian Miscellaneous Collections, vol. 77, No. 3, Feb. 17, 1925 entitled "Provisional Solar-Constant Values, August, 1920 to November, 1924, by C. G. Abbot and Colleagues, furnishes the basis for a further statistical analysis of this important subject. This analysis and the conclusions therefrom will appear in a future issue of the Monthly Weather Review.

difference is less than 0.5 per cent. In the month of October, 1923, when the weather was fine at both stations almost every day, it ran as low as 0.2 per cent. * * *

Work at the two solar-radiation stations.—The results just discussed are, of course, the fruit of the zealous work of our observers in Arizona and Chile. Mount Harqua Hala continues under the direction of Mr. A. F. Moore * * *. At Montezuma, Chile, the station continued in charge of Mr. L. B. Aldrich * * *.

Many comforts and observing improvements have been added at both stations at small expense owing to the ingenuity and hard manual labor of the observers. At both stations all possible days for solar-constant work have been utilized, and with very high accuracy of observation. About 75 per cent of all days were observed in Arizona and above 80 per cent in Chile. The months of July, August, and September, however, were very unfavorable at Harqua Hala, because of unusual cloudiness which prevailed all over that section of the United States. This abnormal state of the sky was indeed made specially prominent by the almost complate failure of all the California observations of the total solar eclipse of September 10, 1923. Many observations of these months must be rejected on account of unfavorable sky.

Mr. W. H. Hoover assisted Mr. Moore for a few weeks in May, 1923. While Mr. and Mrs. Moore were away in Australia setting up near Sydney, a solar-radiation outfit ordered by Rev. E. F. Pigot, of Riverview College, for a committee of interested Australians, Mr. and Mrs. Hoover relieved them at Harqua Hala from July until September. Mr. Hoover was thus prepared by actual field experience to be director of the Argentine Government's new solar-radiation station at La Quiaca.

The outfit for this station was prepared at the Smithsonian Institution after designs of the writer, and the finer parts, such as those of the bolometer and galvanometer, were constructed by Mr. Hoover. Shipment was made in January, 1924, and the station at La Quiaca made ready for solar observing in June, 1924. Thus the Argentine Government is the first agency outside the Smithsonian Institution to undertake regular determinations of the variation of the sun. Their official weather service still receives daily telegraphic reports from our station at Montezuma, Chile, and it will supplement these by its own solar-radiation measurements at La Quiaca.

WOLFER RELATIVE SUNSPOT NUMBERS, 1920-1924

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1920	57.3	50.9	71.9	14.3	33.7	38.8	26.5	18.6	38.7	48.8	24.6	39.9	38.7
1921	28.8	27.6	27.5	30.5	22.3	34.5	42.4	20.8	16.7	16.1	13.4	15.7	24.7
1922	10.2	27.9	60.0	11.4	7.7	5.8	9.7	5.3	5.2	8.1	6.7	18.7	14.7
1923	5.3	1.6	4.0	5.4	3.2	9.0	3.7	0.5	13.7	11.5	7.3	1.1	5.5
1924	0.7	5.7	2.2	11.5	20.7	24.8	28.3	20.0	24.0	25.7	24.5	13.4	16.7

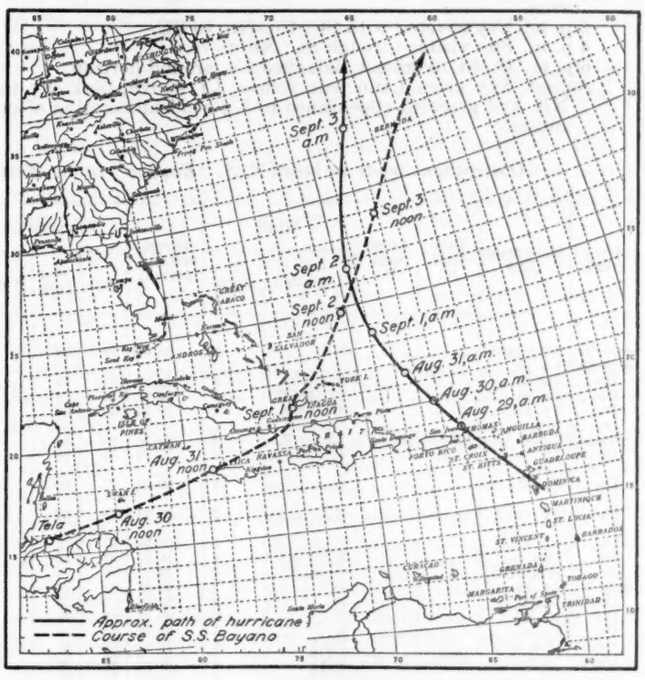
REPORT OF CAPT. F. H. SWAIN ON THE WEST INDIAN HURRICANE OF AUGUST 28–SEPTEMBER 6, 1924

In connection with the West Indian hurricane which prevailed from August 28 to September 6, 1924, Capt. F. H. Swain, master of the British Steamship *Bayano* and a valued observer for the Weather Bureau, rendered a very complete report of weather conditions as observed on board his vessel during the progress of the storm.

The hurricane was first reported in the vicinity of the island of Dominica during the day of the 28th, and in the early morning of the 29th the center passed near the island of St. Thomas, moving slowly in a northwesterly direction. Its intensity was such that severe losses were sustained on several of the smaller islands of the Lesser Antilles.

The *Bayano* was due to sail from Tela (Spanish Honduras) on August 29 for Avonmouth via Bermuda. Captain Swain, receiving radio telegraphic advices regarding the hurricane, doubtless realized that his course might bring him into close proximity to the center unless changed through the exercise of good judgment and seamanship. Fortunately, it happened that the hurricane, although moving but slowly, recurved and passed ahead of the *Bayano* at some distance, so that it was not necessary to maneuver the vessel to avoid the center.

During the days when the course of events was yet uncertain Captain Swain, assisted by his officers, made and recorded a series of weather observations that might well serve as a model for other seamen finding themselves in a similar situation. The Weather Bureau is very glad to publish herewith the major part of this series of observations. A small map is appended on which are shown the respective positions of vessel and storm center on successive days.



DAILY JOURNAL.

NOTE.—From August 28 to September 4 received storm warnings from Washington and various sources.

August 30:

2:15 a. m. Very heavy rain with thunder and lightning until 2:35 a. m., when rain ceased and wind veered to E. by N. and quickly increased to force 9 to 10; first in fierce gusts, then steadily.
3:20 a. m. Wind veering slowly and gradually decreasing.
6 a. m. Continuous light rain. Sky clear to N. and NW.
8 a. m. Extreme visibility over land.
8 p. m. Small Nb. clouds at low altitudes.
Midnight. Wind inclined to back; clouds around horizon.

August 31:

2 a. m. Stars very brilliant; occasional small detached Cu. from ESE.
6 a. m. Very clear; Small detached Nb. from ENE.
4 p. m. Cu.-St. in SW. quadrant.
6 p. m. Cu.-Nb. around horizon.
8 p. m. Streaks of Ci.-St. over sun at sunset.
10 p. m. Squalls of rain working from eastern quadrants.
Midnight. Thin St. around horizon.

September 1:

NOTE.—From 8 p. m. 31st to 5 a. m. September 1 stars showing very brilliant, appearing enlarged with halos around them or as having blurred appearance. Cuban land extraordinarily clear; visible at long distances, although appearing close at hand. Stars reflected in water. Weather appeared hazy, yet land and stars showed through brilliantly.
Heavy clouds over Cuban mountains at sunrise; small detached Ci.-St. to eastward.
8 a. m. Wind increasing and backing to N. by E. when clearing the land.
2 p. m. Cumulus (low) all parts of horizon.
3:30 p. m. Wind dog to NE.; swell rising; Cu.-Nb. to W. and SE.
6 p. m. Ci.-St. and Cu.-Nb. from NE.; swell increasing.
Sunset. Small streaks of St. over sun; occasional light showers.
10 p. m. Cu.-Nb over southern horizon.
Midnight. Wind backing.
2 a. m. Lightning to NE.

September 2:
4 a. m. Thin St. in NE. quadrant; small detached Cu. from NNW.
6 a. m. Thin St. overhead; heavy Nb. to NW.
8 a. m. Thin St. overhead; Nb. to N. and NW.; confused swell.
10 a. m. Thin Ci.-St. in zenith; Cu. and Nb. working from N. quadrant.
Noon. Sky overcast around horizon; heavy confused sea and swell.
2 p. m. Sky covered with St.; Cu.-Nb. to SE.
4 p. m. Sun visible through St.; Nb. to N.
6 p. m. Ci.-St. overhead; detached Cu. around horizon.
Sunset. Sky around sun pale yellow; Ci. above; pink sky to NE. and greenish appearance to E.; wind moderating after sunset.

September 2—Continued.
10 p. m. Cu. and St. banking around horizon SW. quadrant.
Midnight. Detached Cu. from SW. quadrant.
September 3:
2 a. m. Occasional Cu.-Nb. from SW.
3:30 a. m. Light showers.
6 a. m. Nb. around horizon from NE. to S. through SE.
8 a. m. Ci. passing from SW. to NE. Nb. around horizon.
Noon. Heavy Cu. and Nb. to N. and W., with rain showers.
2 p. m. Massive Cu. to SE.
4 p. m. Cu. in S. and SE. quadrant (horizon only).
6 p. m. Thin St. over sun; Cu. to westward.
Sunset. Thin St. above sun; small detached Cu. around horizon.
September 4:
Very good visibility from midnight 3d to daylight 4th off Bermuda.

Observations made on board S. S. "Bayano" in the West Indies during the hurricane of August 28–September 6, 1924

Date (1924)	Local mean time	Latitude N.	Longitude W.	Wind		Barometer (corrected)	Temperature			Weather	Clouds			Sea	Swell
				Direction	Force		Air	Wet bulb	Water		Form	Direction (from)	Amount		
							°	°							
Aug. 29	Midnight			NE	3	29.94	82	78	84	bcvl	Cu., St		5	NE., 2-3	NE., 2.
Aug. 30	2 a. m.														
Do	4 a. m.			E. by S	5-6	29.92	76	75	82	o	Cu., St		10	E'ly, 4	NE., 2.
Do	6 a. m.			SE. by E	5-4	29.91	78	74		od	Cu.-Nb		9	SE. by E., 4	ENE., 2.
Do	8 a. m.			SE. by E	4	29.92	80	76	83	ov	St		9	SE. by E., 3	ENE., 2.
Do	10 a. m.														
Do	Noon	16° 53′	83° 50′	SE. by E	3	29.96	86	80	83	ov	Cu., St		9	SE. by E., 3	ENE., 2.
Do	2 p. m.			E. by S	2	29.94	86	80		ov	Ci., Ci.-St., A.-Cu., Cu.		8	E. by S., 2	ENE., 2.
Do	4 p. m.			E	2	29.93	87	80	85	ov	Ci., Ci.-St., A.-Cu., Cu.	Easterly	10	E., 2	ENE., 2.
Do	6 p. m.			E	2	29.94	85	80		o	Ci., Ci.-St., Cu.-St., Cu.		9	E., 2	ENE., 2.
Do	8 p. m.			E	2	29.96	83	79	84	bv	Cu., Cu.-Nb		1	E., 2	ENE., 2.
Do	10 p. m.			E. by N	2	29.97	83	79		bv	Ci., Cu		1	E., 2	ENE., 2.
Do	Midnight			E. by N	2	29.97	83	79	84	bv	Ci., Cu., St	ESE	1	E., 2	ENE., 2.
Aug. 31	2 a. m.			E	2	29.93	82	78		bv				E., 2	ENE., 2.
Do	4 a. m.			E	2	29.93	82	78	83	bv				E., 2	ENE., 2.
Do	6 a. m.			E	2	29.93	83	78		bv	Cu.-Nb	ENE	1	E., 2	ENE., 2.
Do	8 a. m.			E	3	29.96	85	79	84	bv	Cu.-Nb		1	E., 2	ENE., 2.
Do	10 a. m.			ENE	4	29.98	86	80		bv	Cu		2	E. by N., 2	ENE., 2.
Do	Noon	18° 29′	78° 31′	ENE	4	29.97	87	80	84	bv	Cu		2	E. by N., 3	ENE., 3.
Do	2 p. m.			ENE	4	29.95	87	80		bcv	Ci.-St., Cu.-St		3	ENE., 3	ENE., 2.
Do	4 p. m.			ENE	4	29.93	85	80	84	bv	Ci., Cu.-St		2	ENE., 3	ENE., 2.
Do	6 p. m.			ENE	4	29.92	83.5	78		bv	Cio.-St., Cu.-Nb		2	ENE., 3	ENE., 2.
Do	8 p. m.			ENE	3	29.92	83	78	83	bv	Cu., Cu.-Nb		2	ENE., 2	ENE., 2.
Do	10 p. m.			ENE	2	29.94	83.5	79		bv	Cu., Cu.-Nb	E	5	ENE., 1	ENE., 2.
Do	Midnight			NE. by N	2	29.95	82	78	84	bv	Cu., Cu.-Nb		2	NE., 1	ENE., 2.
Sept. 1	2 a. m.			NE	2	29.92	82	77		bv			0	NE., 2	NE., 2.
Do	4 a. m.			NE. by N	2	29.90	80	77	82	bv			0	NE., 2	NE., 2.
Do	6 a. m.			NE. by N	2	29.90	80	77		bv	Ci.-St., Nb		1	NE., 2	NE., 2.
Do	8 a. m.			N. by E	3	29.92	82	78	83	bc	Cu.-Nb		1	N. by E., 2-3	NE., 2.
Do	10 a. m.			N. by E	2-3	29.93	89	80		b	Cu.-St		1	N. by E., 3-2	NE., 1.
Do	Noon	20° 56′	73° 48′	N. by E	3	29.93	86	79	83	b	Ci.-Cu		1	N. by E., 2-3	NNE., 2.
Do	2 p. m.			N. by E	3	29.92	86	79		bc	Cu., Ci.-St		1	N. by E., 2-3	NE. by N., 3.
Do	4 p. m.			NNE	3-4	29.90	85	79	84	bc	Cu., A.-St	NE	3	NNE., 3	NE. by N., 4.
Do	6 p. m.			N	4	29.87	83.5	78		bc	Ci., Ci.-St., Cu.-Nb.	NE	1	N., 3	NE., 5.
Do	8 p. m.			N	4	29.87	82	78	82	b	Cu.-Nb		1	N., 3	NE., 5.
Do	10 p. m.			N	4	29.87	82	77		b	Cu.-Nb		1	N., 3	NNE., 5.
Do	Midnight			N. by W	3	29.84	81	77	82	b			0	N. by W., 2-3	NNE., 5.
Sept. 2	2 a. m.			NNW	3	29.84	80	77		bl	Cu.-St		1	N. by W., 3	NE. by N., 5.
Do	4 a. m.			NW. by N	3	29.83	81	77	82	b	Cu.-St	NNW	1	NNW., 2	NE. by N., 5-6.
Do	6 a. m.			NW. by W	4	29.83	81	77		c	St., Cu.-Nb		5	NW., 3	ENE., NW., 5-6.
Do	8 a. m.			WNW	5	29.80	82	78	81	c	Ci.-St		5	NNW., 4	ENE., 5-6.
Do	10 a. m.			WNW	5-6	29.80	82	78		c	Cu.-St	N	6	WNW., 4-5	NW., 5-6.
Do	Noon	24° 47′	70° 21′	WNW	6	29.81	84	79	81	oc	Cu., Cu.-St		7	WNW., 5	ENE., NW., 6.
Do	2 p. m.			W	6	29.80	84	79		oc	Ci., Ci.-St., Cu., Cu.-St.		10	W. by N., 5	NE., NW., 6.
Do	4 p. m.			WSW	6	29.80	83	79	80	oc	Ci.-St., Cu		9	WSW., 5	NE., WNW., 6.
Do	6 p. m.			SW. by W	6	29.80	81	78		bc	Ci.-St., Cu		4	SW. by W., 5	E., confused, 6.
Do	8 p. m.			SW. by W	6-5	29.82	80	77	80	b	Cu		1	SW. by W., 5	E., confused, 6.
Do	10 p. m.			SW	5-6	29.82	80	77		b	Cu.-St		1	SW., 5	E., confused, 6.
Do	Midnight			SW	5-6	29.82	80	77	80	b	Cu		1	SW., 4-5	E., confused, 6.
Sept. 3	2 a. m.			SW	6-7	29.84	80	77		b	Cu., Cu.-Nb		1	SW., 5	E., confused, 6.
Do	4 a. m.			SW	6-7	29.84	79	77	79	b	Cu., Cu.-Nb		1	SW., 4-5	ESE., confused, 6.
Do	6 a. m.			SW	6-7	29.88	79	76		b	Ci., Nb		2	SW., 5-6	W., ESE., 6-5.
Do	8 a. m.			SW	6-7	29.90	80	76	82	b	Ci., Nb		2	SW., 6	W., ESE., 6-5.
Do	10 a. m.			SW	6-7	29.93	83	77.5		b	Ci., Cu		1	SW., 6	W., ESE., 6-5.
Do	Noon	28° 48′	67° 08′	SW	6	29.94	84	79	79	bc	Cu.-Nb		6	SW., 6	W., ESE., 6-5.
Do	2 p. m.			SW	5	29.94	85	80		bc	Cu		3	SW., 5	WSW., ESE., 5.
Do	4 p. m.			SW	5	29.94	84	78	81	b	Ci., Ci.-Cu., Cu		2	SW., 5	W., SE., 5
Do	6 p. m.			SW	5-4	29.95	82.5	78		b	Cu.-St		1	SW., 5	S., ESE., W., 5.
Do	8 p. m.			SW	5	29.97	80	77	80	bv	Cu		1	SW., 5-4	W., S., ESE., 5.
Do	10 p. m.			NW	2	29.99	80	76.5		bv	St		1	SW., 4	W., S., ESE., 5.
Do	Midnight			NW	2	29.99	79	76	79	bv	St		1	SW., 4	W., ESE., 5.
Sept. 4	2 a. m.			NW	2	30.00	78	75		bv		NNW		NW., 3	W., SE., 5.
Do	4 a. m.			NW	2	30.01	78	75	78	bv				NW., 2	W., SE., 5.

AN EXTRAORDINARY CASE OF SUPERSATURATION IN THE FREE AIR

By J. JAUMOTTE, Director, Royal Meteorological Institute of Belgium

(Abstracted from *Ciel et Terre*, XLI, no. 3, March, 1925, pp. 42–49, 3 figs.)

An airplane flight for meteorological observation on June 11, 1924, carried out by the institute in the course of its daily sounding of the atmosphere, revealed a very unusual moisture condition at an altitude of some 5,000 meters. The plane having passed through, at 4,500 and 4,800 meters, respectively, rain and fairly dense hail, on reaching 5,000 meters an icy deposit varying from 6 to 10 cm. in thickness was observed to form on the forward edges of the wings and struts, the atmosphere at the time seeming to be perfectly clear. The deposit appeared to be rime, except that the forward part of it was composed of transparent ice. There had been no deposit previous to arriving at 5,000 meters.

The deposit seems to have lasted about seven minutes, this estimate being based on the fact that the meteorograph curves indicated a closing of the ventilating apertures by ice for that length of time, following which the apertures were again free due to evaporation of the deposit. The speed of the plane during the time the ice existed was 130 km. per hour.

At this speed, in seven minutes the plane traveled 15,000 meters. Therefore for each cm.^{2} of area of cross section of a strut, a volume of air of 1.5 m.^{3} was passed through, capable at saturation and at a temperature of $-15°$ C. of containing 2.2 gm. of water. Assuming for a deposit 6–8 cm. thick a deposit per cm.^{2} of strut area of 5 gm., this would indicate a relative humidity of 325 per cent.

The existence of water *vapor* to the extent thus demanded is inadmissable. Moreover, owing to the streamlining of the struts, etc., only a very small part of the volume of air involved could come into contact with the surfaces. It must be concluded, then, that in spite of the "clearness" of the atmosphere it nevertheless contained extremely minute subcooled water droplets, which were precipitated upon the struts because inertia forced them out of the deflected air stream which passed the struts.

The basis of the author's belief in the possibility of the existence of such invisible droplets is explained mathematically and with reference to J. J. Thomson's theories on condensation and to those of C. T. R. Wilson on the appearance of fog in the absence of large ions as condensation nuclei.

The author's conclusions are:

1. Air may at certain altitudes be completely deprived of the usual condensation nuclei (dust, large ions, certain residual water droplets).

2. The quantity of water (vapor *plus* invisible droplets) contained in that air may reach a value corresponding to an extreme supersaturation, and consequently small ions in it may in certain cases form nuclei for the production of lofty clouds (C. T. R. Wilson). It is likely that supersaturation is an exceptional phenomenon at 5–6 km., but may occur frequently at mean cirrus level.—*B. M. V.*

MILD WINTER (1924–25) IN NORTHWESTERN EUROPE

The winter of 1924-25 in France, the British Isles, and Scandinavia was a mild one, especially in northern Scandinavia.

From an article by M. Charles Rabot in La Nature, February 7, 1925, and from press dispatches, we excerpt the following.

At Oslo [Christiania] the mean temperature for December, 1924, was 6° C. above normal—the greatest excess in a century.

The extraordinary temperature of 6.8° C. (44.2° F.) was recorded near North Cape on January 21, 1925. In all Norway snowfalls were infrequent and the very unusual spectacle of a snowless Christmas was presented in the greater part of the country. Lack of snow has paralyzed the work of removing cut timber in southern Norway and elsewhere in the Baltic basin. Cutting has been accomplished as usual, but it has not yet been possible to arrange for sledding it to the banks of streams down which it is floated to shipping ports.

In England the winter was remarkable, more for the heavy rain than the cold. A cold blustery spell, however, set in during the first half of March.

In Copenhagen the past winter is said to have been the mildest in three centuries.—*A. J. H.*

BIBLIOGRAPHY

C. FITZHUGH TALMAN, Meteorologist in Change of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Abbot, C. G., and others.
Provisional solar-constant values, August, 1920, to November, 1924. Washington. 1925. 38 p. illus. 24½ cm. (Smithsonian misc. coll., v. 77, no. 3.)

Alexander, William H.
Climatological history of Ohio. [Columbus. 1923.] 745 p. front. illus. (maps, ports). 23 cm. [Ohio state univ., Columbus. Engin. exper. sta. Bull. no. 26.]

American automobile association.
Snow removal. Washington. [c1924.] 32 p. map. 30½ cm.

Ångström, Anders.
On continuous radiation records and their bearing upon geophysical problems. Göteborg. 1924. p. 130–134. illus. 24 cm. (Extr.: Förhandlingar 17 skandinaviska naturforskaremötet i Göteborg, 1923.)

Bauer, Louis A.
Terrestrial magnetism and electricity at the Madrid meeting, October 1924. Baltimore. 1924. 10 p. 25 cm. (Internat. geod. & geophys. union. Sec. terr. mag. & elec. Bull. no. 4.)

Bowman, Isaiah.
Desert trails of Atacama. New York. 1924. v, 362 p. front. illus. plates. maps. diagrs. 26 cm. [Rainfall of the desert, p. 40.]

Commission internationale des renseignements synoptiques.
Grôupe d'essai pour l'observation du ciel. n. p. n. d. chart. 21½ cm.

Geigel, Richard.
Wetter und Klima, ihr Einfluss auf den gesunden und auf den kranken Menschen. München. 1924. iv, 419 p. 21½ cm.

Gutiérrez-Lanza, M[ariano.]
Huracan sin precedente octubre 1924. Habana. 1924. 16 p. plates. 23½ cm.

Hamilton, J. O.
Some weather studies. Manhattan, Kansas. 1909. 22 p. illus. 23 cm. (Agric. educ. v. 2, no. 1, Sept., 1909.)

Hepner, Frank E.
Climatological data for Wyoming. p. 65–160. illus. plates (fold.). 23 cm. (Univ. Wyoming Agric. exper. sta. Bull. no. 139, June, 1924.)

Hildebrandsson, H. H.
Hugo Emanuel Hamberg. Minnesteckning. Stockholm. n. d. p. 247–264. port. 22 cm. (K. Svenska vetenskapsakad. årsbok. 1924.) [Obituary. With portrait and list of his publications.]

Horn-d'Arturo, G.
Le "ombre volanti." Roma. 1924. p. 131–181. illus. 24½ cm. (Pubb. dell'Osserv. astron. R. Univ. di Bologna. v. 1, n. 6.) (Estr.: Mem. soc. astron. ital. n. s. v. 3.)

Huntington, Ellsworth.
Civilization and climate. 3d ed., rev. and rewritten. New Haven. 1924. xix, 453 p. illus. diagrs. 23½ cm.

[Italy.] R. Uff. cent. di met. e geof.
Riassunto annuale delle osservazioni meteorologiche eseguite negli osservatori italiani durante gli anni solari 1921 e 1922. Roma. 1924. 37 p. 26½ cm.

Kähler, K.
Die Elektrizität der Gewitter. Berlin. 1924. 148 p. illus. 23 cm. (Sammlung Borntraeger Bd. 3.)

López, Elpidio.
Anuario astronómico y meteorológico para 1918. Arreglado exclusivamente para la República Mexicana. Paris. 1918. 160, iii p. plates. 18½ cm.

Martonne, Emm[anuel] de.
Traité de géographie physique . . . Ed. 4. Paris. 1925. v. 1. Notions générales, climat, hydrographie. xi, 496 p. illus. plates (part fold.) 25½ cm.

Mauchly, S. J.
Atmospheric electricity. p. 37–40. illus. 24 cm. (Repr.: QST, Nov., 1924.)

New York (state). Conservation commission.
Annual report. 14th. 1924. Albany. 1925. 251 p. illus. front. plates (fold.) 23 cm. [Weather stations in connection with forest fires, p. 142, ffg. Wing spread of gipsy moth, p. 168, ffg.]

Peek, F. W.
Lightning. p. 141–182. illus. 24½ cm. (Repr.: Journ. Franklin inst. v. 199, no. 2, Feb., 1925.)

Smyrna.
Smyrna climatic chart. General monthly average of meteorological observations made daily during nine consecutive years. n. p. n. d. sheet. 21½ cm.

Vegard, L.
Auroral spectra at different altitudes and the origin of the green auroral line . . . Christiania. 1923. 6 p. illus. 27 cm. (Videnskapsselskapets skrifter. I. Mat.-naturv. klasse. 1923. No. 9.)
Auroral spectrum and the upper strata of the atmosphere . . . Kristiania. 1923. 18 p. 27½ cm. (Videnskapsselskapets skrifter. I. Mat.-naturv. klasse. 1923. No. 8.)
Distribution of matter in the highest strata of atmosphere . . . Kristiania. 1923. 18 p. illus. 27½ cm. (Videnskapsselskapets skrifter. I. Mat.-naturv. klasse. 1923. No. 10.)

RECENT PAPERS BEARING ON METEOROLOGY

The following titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

American journal of science. New Haven. (5) v. 9. March, 1925.

Coleman, A. P. Late paleozoic climates. p. 195–203.

American meteorological society. Bulletin. Worcester, Mass. v. 6. 1925.

Alter, Dinsmore. Application of Schuster's periodogram to long rainfall records. p. 8–9. (Jan.) [Abstract of discussion only.]

Anderson, J. B. Some meteorological encounters of the Shenandoah. p. 19–20. (Jan.) [Abstract.]

Calvert, E. B. Fruit-spray and harvest-weather forecast work of the Weather Bureau in New York State. p. 15–16. (Jan.) [Abstract.]

Cline, I. M. Distribution of rainfall in tropical cyclones. p. 10. (Jan.) [Abstract.]

Gregg, W. R. Some outstanding aerological problems. p. 22–23. (Jan.) [Abstract.]

Humphreys, W. J. The variation of the wind with height. p. 20–21. (Jan.) [Abstract.]

Hunter, H. C. Tornadoes of the United States, 1916–1923. p. 10. (Jan.) [Abstract.]

Jensen, J. C. Changes in the potential gradient during thunderstorms. p. 16. (Jan.) [Abstract.]

Kincer, J. B. Climate and weather influence on the fruit industry of the United States. p. 12–14. (Jan.) [Abstract.]

Meisinger memorial. p. 21–22. (Jan.)

Talman, Charles Fitzhugh. The vocabulary of weather and climate. p. 10–11. (Jan.) [Abstract.]

Thiessen, A. H. Weather forecasting for long airplane flights. p. 18–19. (Jan.) [Abstract.]

Vaughan, Lloyd D. On the mechanism of fluid rotation in the atmosphere. p. 17–18. (Jan.) [Abstract.]

Ward, R. De C. Teaching climate by lantern slides. p. 12. (Jan.) [Abstract.]

Bjerknes, V. Simple weather maps by radio. p. 37. (Feb.) [Abstract.]

Fergusson, S. P. The use of duralumin in the construction of apparatus. p. 36–37. (Feb.) [Abstract.]

Humphreys, W. J. Ice ribbons. p. 38. (Feb.) [Abstract.]

Patterson, J. The theory of the anemometer. p. 35–36. (Feb.) [Abstract.]

Tripp, Frances V. Heliotherapy. p. 33–34. (Feb.)

Tripp, Frances V. Solar climate. p. 30–33. (Feb.)

Tripp, Frances V., & Brooks, Charles F. Solar radiation and the atmosphere. p. 25–30. (Feb.)

Voorhees, J. F. A preliminary study of effective rainfall. p. 38. (Feb.) [Abstract.]

Annalen der Hydrographie und maritimen Meteorologie. Berlin. 52. Jahrg. 1924.

Altberg, W. Die physikalischen Bedingungen der Eisbildung auf dem Grunde von Flüssen und Seen. p. 225–229. (H. 10.); p. 273–275. (H. 11.)

Castens, Gerhard. Aus der Praxis des Hamburger Flughafen-Meteorologen. p. 241–244. (H. 10.)

Iswekow, B. Das verallgemeinerte Margulessche Problem. p. 234–240. (H. 10.)

Mey, A. Die Wetterwarte Königsberg i. Pr. p. 229–233. (H. 10.)

Archives des sciences physiques et naturelles. Genève. v. 6. Novembre–Décembre 1924.

Piccard, Auguste. La foudre et le ballon libre. p. 405–406.

Association of American geographers. Annals. Albany. v. 14. December, 1924.

Davis, W. M. The progress of geography in the United States. p. 159–216. ["Climate and weather," p. 173–177.]

Astronomical society of the Pacific. Publications. San Francisco. v. 36. February, 1925.

Humphreys, W. J. Note on the green ray. p. 20.

Astronomie. Paris. 39. an. 1925.

Gazaud, L. Sur les zones de silence. p. 93–94. (Fév.)

Besson, Louis. Sur les variations barométriques en Portugal. p. 124–129. (Mars.)

Giao, Antoine. Sur la périodicité des minima barométriques dans le sud du Portgual. p. 121–124. (Mars.)

British association for the advancement of science. Report of the 92d meeting. Toronto. 1924.

Bjerknes, V. The forces which lift aeroplanes. p. 367. [Abstract.]

Bjerknes, J. The importance of atmospheric discontinuities for practical and theoretical weather forecasting. p. 364. [Abstract.]

Coleman, A. P. Pre-Cambrian climates. p. 390–391. [Abstract.]

Dawson, W. Bell. Effect of wind on the tide. p. 372. [Abstract.]

Gregory, J. W. Inter-racial problems and white colonization in the tropics. p. 125–147. [Discusses effects of tropical climate, p. 136–142.]

Humphreys, W. J. Rainmaking. p. 368. [Abstract.]

Humphreys, W. J. The relation of wind to height. p. 364. [Abstract.]

Kimball, H. H. The determination of daylight intensity from automatic records of total solar and sky radiation. p. 368. [Abstract.]

Marvin, C. F. Let us simplify the calendar and publish statistical data in standardised summaries. p. 368–369. [Abstract.]

British association for the advancement of science—Continued.

Owens, J. S. The automatic measurement of atmospheric pollution. p. 367–368. [Abstract.]

Owens, J. S. Haze observations. p. 365. [Abstract.]

Patterson, J. Upper-air observations in Canada. p. 368. [Abstract.]

Richardson, L. F. Turbulence and temperature-gradient among trees. p. 364–365. [Abstract.]

Shaw, Sir Napier. If the earth went dry. p. 362. [Abstract.]

Stupart, Frederic. The variableness of Canadian winters. p. 362–363. [Abstract.]

Thomson, A. Upper wind observations at Samoa, 1923–24. p. 372. [Abstract.]

Whipple, F. J. W. The diurnal variation of pressure: facts and theories. p. 364. [Abstract.]

California citrograph. Los Angeles. v. 10. April, 1925.

Smith, Willard. Wind damage as related to quantity and quality production of oranges. p. 196; 206–207.

Ciel et terre. Bruxelles. 40 année. Mars 1925.

Jaumotte, J. Un cas de sursaturation extraordinaire dans l'atmosphère libre. p. 42–49. (See p. 79, this REVIEW.)

Engineering news-record. New York. v. 94. March 26, 1925.

Tornado destruction in southern Illinois. p. 522.

France. Académie des sciences. Comples rendus. Paris. t. 180. 1925.

Barbaud, A., & Le Petit, R. Mesure du vent en avion et correction de ses effets sur la route suivie. p. 368–370. (2 fév.)

Dauzère, C. Sur la vase atmosphérique et la mer de nuages. Observations faites au Pic du Midi. p. 452–454. (9 fév.)

Bureau, R. Les atmosphériques. Leur classification. Leurs propriétés thermodynamiques. p. 529–532. (16 fév.)

Athanasiu, G. Sur la sensibilité des actinomètres à électrodes de mercure. p. 587–589. (23 fév.)

Lugeon, Jean. Relations entre diverses discontinuités météorologiques et les oscillations hertziennes parasites au voisinage des chaînes de montagnes. p. 594–597. (23 fév.)

Petitjean, L. Sur une discontinuité stationnaire en Méditerranée occidentale. p. 597–598. (23 fév.)

Heating and ventilating magazine. New York. v. 22. February, 1925.

Yagloglou, C. P., & Miller, W. Edw. Effective temperature with clothing. p. 63–65.

Helwan observatory. Bulletin no. 30.

Shaw, H. Knox-. Note on observations of solar radiation made at Harqua Hala and Montezuma, 1920 October to 1922 August. p. 85.

Shaw, H. Knox-. Observations of the solar radiation received through a constant air-mass. p. 81–84.

Journal de physique et le radium. Paris. t. 6. Janvier 1925.

Kartschaguin, V. Polarisation de la lumière diffuse du ciel. p. 10–19.

Marine observer. London. v. 2. March, 1925.

Smith, H. T. Marine meteorology, history and progress. p. 33–35.

Meteorologia pratica. Montecassino. Anno 5. 1924.

Paoloni, B. Senza l'aiuto della meteorologia e della radiotelegrafia lo Zeppelin R. 3 avrebbe raggiunto l'America? p. 180–181. (Sett.-ott.)

Stabarin, Alberto. I fenomeni elettrici atmosferici e la protezione degli edifici dalle scariche temporalesche. p. 189–202. (Sett.-ott.) [Summary of paper by U. Bordoni.]

Crestani, G. Il pluviometro e il vento: ricerche sperimentali. p. 213–215. (Nov.-dic.)

Eredia, Filippo. La misura della radiazione solare. p. 208–211. (Nov.-dic.)

Eredia, Filippo. La riforma del calendario gregoriano. p. 211–212. (Nov.-dic.)

Eredia, Filippo. Sul modo di indicare sinteticamente il clima di una località. p. 205–208. (Nov.-dic.)

Rossi, Alberto. Condizioni climatiche ed atmosferiche dell' Istria. p. 215–218. (Nov.-dic.)

Meteorological magazine. London. v. 59. October, 1924.

The aeroplane as an aid to pilot balloon work. p. 215–216.

Glasspoole, J. The unprecedented rainfall at Cannington. p. 205–207.

Ockenden, C. V. The penetrating radiations of the upper air. p. 220–221. [Results of investigations by Millikan.]

Sutton, J. R. The control of fire-damp by atmospheric pressure. p. 211–212.

Whipple, F. J. W. The circulation of atmospheric electricity; some new evidence. p. 201–204.

Nature. London. v. 115. 1925.

Owens, J. S. London fog of January 11–12, 1925. p. 121. (Jan. 24.)

Nature. London. v. 115. 1925—Continued.

Dunlop, W. R. Rainfall correlations in Trinidad. p. 192–193.

Simpson, G. C. The future of the Meteorological office. p. 226. (Feb. 14.)

Johnson, N. K. Short-period variations of the wind. p. 263–264. (Feb. 21.)

Cave, C. J. P. The future of the Meteorological office. p. 378. (March 14.)

McLennan, J. C. The auroral green line. p. 382. (March 14.)

Nature. Paris. 53 année. 1925.

Touchet, Em. Un phénomène d'optique atmosphérique. p. 67–68. (31 janv.)

Mascart, Jean. Géographie et météorologie. p. 92–94. (7 fév.)

Rabot, Charles. Le début de l'hiver 1924–1925 dans le nord scandinave. suppl. p. 41. (7 fév.) [Remarkably mild winter in northern Europe.]

Rabot, Charles. L'hiver de 1924–1925 au Spitsberg. suppl. p. 81. (14 mars.) [Unprecedented mild weather and absence of ice.]

Nature magazine. Washington, D. C. v. 5. 1925.

Talman, Charles Fitzhugh. The story of the winds. p. 153–157. (March.)

Talman, Charles Fitzhugh. When the waters break loose. p. 228–232. (April.)

Naturwissenschaften. Berlin. 13. Jahrgang. 1925.

Eckardt, Wilh. R. Die klimatischen Verhältnisse der geologischen Vergangenheit im Lichte von Alfred Wegeners Hypothese der Kontinentenverschiebungen. p. 84–89. (30. Jan.)

Albrecht. Wolkenuntersuchungen auf dem hohen Sonnblick. p. 110. (6. Feb.) [Abstract.]

König. Die Wetterlage bei der Amerikafahrt des Zeppelinluftschiffes. p. 110. (6. Feb.) [Abstract.]

v. Ficker. Ballonfahrten bei Föhn. p. 110–111. (6. Feb.) [Abstract.]

Kassner, [Carl.] [Der] Wolkenbruch am 21. Juni 1924 in Berlin. p. 223. (13. März.) [Abstract.]

Wussow, [G.] Die Häufigkeit der Niederschlagstage in Deutschland nach Stufenwerten der Nidereschlagsmenge und ... die Darstellung der Niederschlagsverteilung in Deutschland durch Isanomalen. p. 222–223. (13. März.) [Abstract.]

Physical society of London. Proceedings. London. v. 37. February 15, 1925.

A discussion on ionization in the atmosphers and its influence on the propagation of wireless signals, held November 28, 1924, at the Imperial college of science, South Kensington, S. W. p. 1D–50D.

Philosophical magazine. London. v. 48. December, 1924.

Larmor, Joseph. Why wireless electric rays can bend round the earth. p. 1025–1036.

Physikalische Zeitschrift. Leipzig. 25. Jahrgang. 1924.

Gockel, A. Über die Ionisation der Atmosphäre. p. 646–647. (No. 23.) [Abstract.]

Bongards, H. Messungen des Gehalts der Luft an radioaktiven Zerfalls-producten vom Flugzeug aus. p. 679–682. (No. 24.) [Abstract.]

Vegard, L. Das Nordlichtspektrum und die Höheren Atmosphärenschichten. p. 685–689. (No. 24.) [Abstract.]

Wigand, A. Luftelektrische Untersuchungen bei Flugzeugaufsteegen. p. 684–685. (No. 24.) [Abstract.]

Reale accademia dei Lincei. Atti. Roma. Rendiconti. v. (5)33, fasc. 10. 1924.

Horn d'Arturo, Guido. Sulle ombre volanti visibili durante le ecclissi solari. p. 410–413.

Revue générale des sciences. Paris. 36. année. 28 février 1925.

Magnan, A. L'énergie interne du vent et le vol à voile. p. 101–111.

Royal astronomical society of Canada. Journal. Toronto. v. 19. January–February, 1925.

Patterson, J. Meteorology at the British association for the advancement of science and the international mathematical Congress. p. 4–9.

Royal meteorological society. Quarterly journal. London. v. 50. October, 1924.

Brooks, C. E. P. The distribution of rainfall over Uganda, with a note on Kenya Colony. p. 325–338.

Clark, J. Edmund, Margary, Ivan D., & Marshall, Richard. Report on the phenological observations in the British Isles, from December, 1922, to November, 1923. p. 277–323.

Dines, L. H. G. A simple electrical time-marking system for use with self-recording meteorological instruments p. 373–380.

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Royal meteorological society—Continued.
Douglas, C. K. M. Further researches into the European upper air data, with special reference to the life history of cyclones. p. 339–363.
Lewis, Lilian F. The effect of the source of air on its temperature at 4,000 feet and 10,000 feet. p. 365–371.
Royal society of London. Proceedings. London. Ser. A. v. 107. February, 1925.
Jeffreys, Harold. On the formation of water waves by wind. p. 189–206.
Science. New York. v. 61. March 20, 1925.
Cady, Walter G. Shadow bands. p. 312.
Scientific American. New York. v. 81. April, 1925.
Shoveling snow with T. N. T. p. 259.
Scientific monthly. New York. v. 20. April, 1925.
Shaw, Napier. The circulation of the atmosphere. p. 436–441.
Seismological society of America. Bulletin. Stanford univ. v. 14. September, 1924.
Visher, Stephen S. Tropical cyclones and earthquakes. p. 181–184.
Zeitschrift für Instrumentenkunde. Berlin. 45. Jahrgang. January, 1925.
Becker, E. Winddruck und Windrichtungsanzeiger mit elektrischer Übertragung. p. 44–48.

SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING FEBRUARY, 1925

By HERBERT H. KIMBALL, In Charge, Solar Radiation Investigations

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, **52**: 42 and January, 1925, **53**: 29.

From Table 1 it is seen that solar radiation intensities averaged considerably below normal values for February at all three stations.

Table 2 shows that the total solar and sky radiation received on a horizontal surface averaged below normal at the three stations for which weekly normal values have been determined. The deficiency was especially marked at Madison, Wis.

At Washington, skylight polarization measurements made on five days give a mean of 51 per cent, with a maximum of 58 per cent on the 27th. These values are also below the corresponding averages for February at Washington.

No polarization measurements were obtained at Madison, as the ground was continuously covered with snow.

The data from all the stations unites in showing unusually low atmospheric transmission of solar radiation. This may have been due in part to low wind velocities. which permitted an unusual accumulation of smoke of local origin to collect over the cities in or near which the various observing stations are located. The high average temperature, and the accompanying high water-vapor content of the atmosphere no doubt also contributed to the diminution of atmospheric transmission.

TABLE 1.—*Solar radiation intensities during February, 1925*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	8 a.m.	Sun's zenith distance									Noon
		78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Feb. 3	1.52						1.22	0.98			1.88
4	2.26				1.00		0.89				2.62
5	2.87	0.49	0.60	0.78	1.04		1.08	0.91	0.74		3.63
6	4.37	0.58	0.69	0.79	1.03		0.65	0.59			4.75
18	2.26	0.48	0.68	0.95	1.20	1.54	1.21	0.97	0.82	0.69	2.26
19	3.63		0.54	0.73							3.45
20	3.99	0.68	0.81	0.93	1.18		1.18	0.95			2.74
26	3.99			1.16			1.31				1.24
27	1.12			0.91	1.16		1.24	1.06	0.90	0.77	1.07
28	1.32	0.47	0.62	0.85	1.11	1.37					1.60
Means		0.54	0.66	0.89	1.10		1.10	0.91	0.82	0.73	
Departures		−0.17	−0.15	−0.08	−0.06		−0.08	−0.06	−0.02	−0.03	

TABLE 1.—*Solar radiation intensities during February, 1925*—Con.

Madison, Wis.

Date	8 a.m.	Sun's zenith distance									Noon
		78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Feb. 5	4.57	0.91	1.03	1.20	1.35	1.52	1.34				4.95
6	4.17				1.14		1.10				5.36
13	1.68				1.39		1.41	1.23			1.88
14	1.88		1.02	1.15	1.30	1.47					2.49
17	0.91						1.26				1.60
27	0.51		1.16	1.28	1.45	1.63					1.60
Means		(0.91)	1.07	1.21	1.33		1.28	(1.23)			
Departures		−0.03	−0.05	−0.02	−0.04		−0.08	+0.05			

Lincoln, Nebr.

Feb. 5	4.37				1.31	1.55	1.31	1.11		0.82	5.79
11	2.26		1.01	1.21	1.42	1.60	1.22	1.07		0.92	2.06
21	3.99		0.81								4.37
23	4.37						1.20				4.75
Means			(0.91)	(1.21)	(1.36)		1.24	(1.09)		(0.87)	
Departures			−0.13	+0.01	−0.03		−0.10	−0.08		−0.04	

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation					Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Washington	Madison	Lincoln
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 29	200	167	266	104	140	+2	−33	+21
Feb. 5	194	160	227	86	128	−22	−57	−40
12	184	227	312	135	149	−50	−12	+18
19	225	135	255	66	183	−33	−124	−64
Excess or deficiency since first of year on Jan. 25						−1,134	−1,834	−700

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The following table shows the average sea-level pressure for the month at a number of land stations on the coast and islands of the North Atlantic. The readings are for 8 a. m., 75th meridian time, and the departures are only approximate, as the normals were taken from the Pilot Chart and are based on Greenwich mean noon observations, which correspond to those taken at 7 a. m., 75th meridian time.

Stations	Average pressure	Departure
	Inches	*Inches*
St. Johns, Newfoundland	30.03	+0.20
Nantucket	30.05	−0.01
Hatteras	30.08	−0.05
Key West	30.07	−0.02
New Orleans	30.09	−0.01
Swan Island	29.94	−0.05
Turks Island	30.08	0.00
Bermuda	30.16	+0.02
Horta, Azores	30.42	+0.23
Lerwick, Shetland Islands	29.39	−0.35
Valencia, Ireland	29.63	−0.27
London	29.68	−0.32

It will be noticed that the average monthly pressure at Horta was considerably above the normal, while at Lerwick it was below. This denotes that both the North Atlantic HIGH and Icelandic LOW were unusually well developed, and the steep gradient between these two centers of action was responsible for the frequency of heavy westerly winds in the intermediate territory. At Horta the barometric readings ranged from 30.24 inches on the 28th to 30.66 inches on the 6th, and at Lerwick from 28.80 inches on the 8th and 10th to 29.90 inches on the 19th. At the latter station there was a period of low pressure from the 8th to the 12th, the *highest* reading being 28.98 inches on the 11th.

Over the eastern section of the steamer lanes the number of days with winds of gale force was above the normal, due to the conditions stated above. In the region between the 40th meridian and the American coast, however, comparatively moderate weather prevailed during the greater part of the month, although these waters were visited by a few cyclonic disturbances, for the most part of limited extent.

Fog was unusually prevalent over the Grand Banks and in the vicinity of Nantucket Shoals, it being observed on from 15 to 16 days in both localities. Fog was reported on 3 days in the Gulf of Mexico, while the steamer lanes east of the 40th meridian were comparatively clear.

On the 1st there was a LOW central near 53° N., 40° W., that moved slowly northeastward, and on the 5th was in the vicinity of Iceland, although it was impossible to plot its position accurately due to lack of observations.

On the 3d and 4th there was a slight depression between the Bermudas and New York. By the 5th it had deepened considerably, the center on that date being near 40° N., 60° W.

From the 7th to 17th there was a persistent area of low pressure over some part of the region east of the 40th meridian, the storm area varying in extent and intensity from day to day. Charts VIII to XIII show the conditions from February 10 to 15, inclusive. From the 10th to 13th there was also a cyclonic disturbance of limited extent along the American coast as shown on charts VIII to XI.

From the 18th to 21st no well-developed LOW was reported, although vessels in widely scattered localities encountered gales during this period.

From the 22d to 27th the eastern section of the steamer lanes was swept by severe westerly to northwesterly gales, accompanied by rain, hail, and snow, the storm area on the 24th extending as far south as the 40th parallel.

From the 26th to 28th there was also a well developed LOW of limited extent over the region between Hatteras and Newfoundland.

OCEAN GALES AND STORMS, FEBRUARY, 1925

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer (Ins.)	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
North Atlantic Ocean:			° ′	° ′									
Novian, Br. S. S.	London	Boston	48 03 N.	31 53 W.	Jan. 31	2 a., 1st	1st	29.93	SW	SE., 9	W	—, 9	SW-S-SE.
Frederick VIII, Dan. S. S.	Oslo	New York	57 56 N.	18 50 W.	Feb. 1st	10 p., 2d	3d	29.45	SSW	SW., 9	SW	W., 10	SSW-W.
Brasilien, Dan. S. S.	New York	Copenhagen	56 45 N.	22 18 W.	Jan. 30	8 a., 4th	5th	29.12	SE	WSW., 11	W	W., 11	Steady W.
Bay State, Br. S. S.	Dundee	New York	42 50 N.	62 00 W.	Feb. 2	4 a., 3d	5th	29.67	SSE	S., 9	N	—, 10	S-NW.
Shickshinny, Am. S. S.	Savannah	Liverpool	39 35 N.	56 05 W.	5th	4 a., 5th	6th	29.53	S	S., 6	S	—, 8	N-NE.
Cairnvalone, Br. S. S.	Leith	Portland, Me.	58 31 N.	7 28 W.	8th	1 p., 8th	10th	28.85	WSW.	W., 8	W	—, 9	
Van Rensselaer, Du. S. S.	Dover	Barbados	44 09 N.	15 04 W.	10th	3 a., 11th	12th	29.51	SW	N., 7	W	SW., 9	SW-NW-N.
Canadian Importer, Br. S. S.	Norfolk	England	46 25 N.	21 13 W.	12th	11 p., 12th	15th	29.52	WNW	WNW., 9	N	—, 10	Steady WNW.
Maine, Dan. S. S.	do	Copenhagen	54 14 N.	24 18 W.	9th	Noon, 13th	15th	29.27	WNW	NNW., 10	N	NW., 10	WNW-N.
Pennsylvania, Am. S. S.	Port Arthur	Bayonne	32 10 N.	78 30 W.	10th	4 p., 10th	11th	29.80	E	SE., 9	SSE	—, 9	E-SE.
West Modus, Am. S. S.	Galveston	Liverpool	27 46 N.	79 46 W.	11th	5 p., 11th	13th	29.77	W	W., 7	NNW	—, 8	SW-WNW.
Parthenia, Br. S. S.	Glasgow	St. John, N. B.	50 11 N.	32 08 W.	18th	4 a., 19th	20th	29.72	S	S., 9	NNW	—, 10	S-WNW.
Stockholm, Swed. S. S.	New York	Gothenburg	55 46 N.	24 22 W.	21st	Noon, 23d	23d	28.21	W	N	N	WNW., 11	W-NW-W.
Nevisian, Br. S. S.	do	Hamburg	49 10 N.	12 00 W.	22d	4 a., 24th	25th	28.97	W	WSW	W	W., 11	W-S-WSW-W.
Lucellum, Br. S. S.	Norfolk	Ghent	47 21 N.	25 55 W.	22d	10 a., 25th	27th	29.64	SSE	W., 9	NNW	NW., 11	SSE-SW-N.
Westphalia, Germ. S. S.	Cobh	New York	50 05 N.	18 09 W.	25th	—, 25th	27th	28.90	SW	W., 11	NW	W., 12	
Mercier, Belg. S. S.	New York	Antwerp	48 45 N.	16 22 W.	25th	9 a., 26th	26th	28.79	WSW.	W., 10	NW	W., 11	WSW-NW.
Silvercedar, Br. S. S.	Gibralter	New York	40 04 N.	64 30 W.	26th	2 p., 26th	28th	29.16	W	SW., 5	WNW	W., 10	SW-W-WNW.
Scythian, Br. S. S.	London	Boston	42 32 N.	67 03 W.	26th	3 p., 27th	28th	29.39	W	NW., 10	WNW	NW., 10	W-NW-WNW.
North Pacific Ocean:													
West Jena, Am. S. S.	Yokohama	Portland	47 N.	167 45 E.	Jan. 31	6 a., 2d	Feb. 2	28.89		NE	NE	NE., 10	ESE-E-NE.
Can. Skirmisher, Br. S. S.	Victoria	Panama	14 30 N.	95 15 W.	Feb. 3	11 a	3d	29.82	N	N., 9	NW	N., 9	N-NW.
Can. Winner, Br. S. S.	do	do	42 46 N.	124 45 W.	4th	9 a., 5th	6th	29.21	SSW	SW., 9	SW	SSW., 10	S-SSW-WSW.
West Jena, Am. S. S.	Yokohama	Portland	50 N.	161 30 W.	7th	6 p., 7th	8th	29.58	N	N	NW	NW., 10	N-NW.
West Jessup, Am. S. S.	Portland	Yokohama	49 40 N.	134 55 W.	7th	6 p., 7th	8th	28.87	SE	SSW., 5	WNW	NW., 11	SE-SSW-WNW
Hakata Maru, Jap. S. S.	Yokohama	Seattle	45 08 N.	162 18 E.	7th	3 p., 8th	9th	28.78	S	SSW., 11	WSW	SSW., 11	S-SW-WSW.
Emp. of Canada, Br. S. S.	do	Vancouver	50 26 N.	139 32 W.	7th	8 p., 7th	9th	29.11	NNW.	NW., 10	WNW	NW., 12	NW-W-NW.
Hanna Nielsen, Nor. S. S.	Balboa	Brit. Columbia.	41 18 N.	125 51 W.	9th	6 a., 10th	10th	29.47	ESE	SE., 10	S	SE., 11	ESE-SE.
Makawell, Am. S. S.	Hawaii	San Francisco	28 38 N.	144 52 W.	9th	Mid., 9th	10th	30.00	NW	NW., 7	NW	NW., 8	
India Arrow, Br. S. S.	Shanghai	do	37 31 N.	132 50 W.	9th	1 p., 11th	11th	29.32	NW	WNW, 7	NW	NW., 9	Steady.
West Prospect, Am. S. S.	Hongkong	do	32 10 N.	135 15 E.	9th	2 a., 10th	11th	29.80	SE	NW., 7	NW	NNW., 9	SW-W-NW.
Pres. Lincoln, Am. S. S.	San Francisco	Manila	34 50 N.	144 30 E.	10th	9 a	10th	29.53	SSW	SSW., 7	WNW	SW., 8	SSW-SW-W.
Steel Ranger, Am. S. S.	San Pedro	Japan	39 12 N.	152 05 E.	10th	7 p., 10th	11th	29.39	S	S., 7	NW	S., 10	SSW-S-SW.
K. I. Luckenbach, Am. S. S.	do	New York	14 31 N.	96 38 W.	11th	2 p., 12th	12th	29.98	NE	—, 10	NW	NE., 10	Steady.
Africa Maru, Jap. S. S.	Yokohama	Victoria	41 35 N.	154 53 E.	11th	Noon, 11th	13th	29.77	NW	NWW., 7	WNW	WNW., 9	Steady.
West Jessup, Am. S. S.	Portland	Yokohama	50 30 N.	174 45 E.	13th	8 p., 17th	19th	28.39	SE	NNE., 7	N	NE., 11	NE-NNE-N.
Crosskeys, Am. S. S.	Japan	Seattle	48 46 N.	178 42 E.	16th	Noon	16th	28.10	ENE	NNE., 8	SE	NNE., 10	
Pres. Jackson, Am. S. S.	Yokohama	Victoria	49 14 N.	178 36 W.	16th	2 a., 16th	17th	28.03	ENE	E., 9	SE	NE., 10	E-SE.
Africa Maru, Jap. S. S.	do	do	48 55 N.	179 46 W.	16th	Noon, 16th	17th	28.12	NNW	E., 5	SE	S., 10	N-E-S.
West Prospect, Am. S. S.	Hongkong	San Francisco	37 44 N.	172 48 E.	16th	10 a., 17th	18th	29.26	W	W., 9	W	W., 9	Steady.
Tusitala, Am. S. S.	Honolulu	Seattle	38 44 N.	145 05 W.	18th	6 a., 19th	19th	29.50	SSE	W., 10	WSW	W., 10	WSW-W.
Pomona, Am. S. S.	Baltimore	do	40 45 N.	124 45 W.	22d	6 a	22d	29.61	SE	SE., 5	S	SE., 10	SE-S.
West O'Rowa, Am. S. S.	Orient	San Francisco	47 29 N.	178 45 E.	21st	3 p., 21st	23d	28.31	W		WSW	SW., 11	SW-WSW.
West Sequana, Am. S. S.	Hongkong	do	38 51 N.	176 34 W.	23d	Noon, 23d	24th	29.20	SE	SW., 10	WSW	SW., 10	SW-W.
Las Vegas, Am. S. S.	Borneo	do	39 40 N.	160 50 W.	24th	3 p	24th	29.09	S	S., 12	W	S., 12	S-SW.
West O'Rowa, Am. S. S.	Orient	do	47 57 N.	162 34 W.	24th	4 p. 24th	26th	28.27	ENE		SW	SW., 11 SSE., 11	SE-SSE.
Dilworth, Am. S. S.	Cebu, P. I.	Portland	46 48 N.	161 50 W.	24th	1 a., 25th	26th	28.45	ESE	SW., 11	SW	SW., 11 S., 11	SE-SW.
Tacoma, Br. S. S.	Hongkong	San Francisco	38 N.	169 E.	26th	8 a., 26th	27th	29.77	W	W., 10	W	W., 11	
Boren, Swed. S. S.	Manila	do	42 20 N.	169 17 W.	28th	1 p	28th	29.14	S	S., 10	SW	S., 10	S-SSW-SW.
Dellwood, Am. S. S.	Seattle	Alaska	52 58 N.	133 12 W.	28th	10 p	28th	29.76	SSE	SSE., 8	SSE	SSE., 8	SSE-S-SSW.
Tacoma, Br. S. S.	Hongkong	San Francisco	39 N.	179 E.	28th	8 p., 28th	Mar. 1	29.85	S	S., 11	S	S., 11	

NORTH PACIFIC OCEAN

By WILLIS EDWIN HURD

Very little fog was reported from the western half of the North Pacific Ocean during February, 1925, except for scattered observances west of Midway Island and along the coasts of China and Japan. Fog occurred on several days near the 50th parallel east of 170° west longitude. It was frequent along the American coast from San Francisco to nearly as far south as the 20th parallel, and was exceptionally frequent on the California routes to Hawaii between the coast and the 140th meridian. Fog was reported on five days south of the Gulf of Tehuantepec. As on several recent occasions, its appearance here excited comment among seamen. Some of these expressions, being deemed of especial interest, are quoted.

The American steamship *Lena Luckenbach*, San Pedro to Galveston, entered fog on February 20 in 14° 50′ N., 94° 50′ W., and cleared it in 14° 06′ N., 94° W. Said the observer, Mr. R. F. Kelly, second officer:

> Mariners who have sailed these seas for many years have never experienced fog in this part of the globe before.

The American steamship *Swiftwind*, California to Canal Zone, entered fog on the 15th in 14° 36′ N., 95° 39′ W., and cleared it on the 16th in 13° 38′ N., 93° 48′ W. This is the report of the ship's first and second officers, Messrs. S. Knudsen and A. C. Allen:

February 15. 12 noon. Observed heavy black fog on horizon extending from NE. to S. At 1:50 p. m. entered same bank, and at 3:25 ran out of it; water at that time same temperature; air dropping 10°. At that time observed fog bank on horizon extending from west through north to south. This bank was yellowish in color at base changing into black at the top. As we approached same it could be seen to be very dense and seemed to be boiling. We ran into water of 62° at that time, air 76°, and held same until February 16, 2 a. m., the bank cut off with a clear edge into fine and clear weather, water 78°, air 74°.

The American steamship *Corinto*, southward bound, Mr. G. H. Sterne, observer, reported the following:

February 16. When passing Port Angeles Lt., Mex., in 15° 30′ N., 96° 30′ W., there was a thick fog came on. It lasted for 8 hours until we arrived at Salina Cruz. The temperature of air and sea water dropped from 78° to 68° within 30 minutes, and continued throughout the a. m. of date till 11 a. m., when it came back normal, 80°. Engineer had same result with sea water taken 16 feet under the surface. Pilot at Salina Cruz claimed it was the first time they had had fog in 20 years.

More very rough weather occurred over the ocean in February than in any previous month of the cold season, and storm to hurricane winds were reported on seven days. Along the northern routes there were frequent and heavy squalls, as well as longer continued falls, of rain, snow, and hail. The weather was exceptionally stormy and variable over the eastern two-thirds of the routes between the American mainland and Hawaii, and gales of force 8 to 10, and in one instance 11, were reported from this region on 12 days. The American steamship *Mahukona*, made this report concerning the unsettled conditions prevailing from the 13th to 23d:

Weather during most of the voyage has been unfavorable, and the wind continually "boxed the compass." Highest velocity of the wind was fresh breeze.

Honolulu reported exceptionally quiet conditions with a mean wind velocity of 6.6 miles an hour, and an extreme 5-minute velocity of 22 miles from the east, on the 5th, this being the record low maximum wind for the station in February. Honolulu experienced unusually warm weather and scant precipitation. The highest temperature was 82, or next to the high record for February, and the lowest was 65, or the highest minimum of record for the month. The precipitation was very light, being 0.36 inch, or 3.39 inches below the normal.

Some gales occurred in Japanese waters, but no high winds have been reported from the region to the southward. Anticyclonic conditions prevailed along the China coast. The weather was generally quiet in the American Tropics, but vessels encountered strong to whole gales on the 3d, 11th, and 12th to the southward of the Gulf of Tehuantepec.

The pressure movements were active north of the 30th parallel. The Aleutian cyclone, with one or more centers, persisted throughout the month. Its principal center lay in the vicinity of Dutch Harbor, but a secondary center frequently covered the lower part of the Gulf of Alaska, sending offshoot LOWS into the mainland on at least eight different occasions.

On February 8 a depression of considerable magnitude separated from the main area in the gulf, becoming central near 40° N., 145° W., and moved slowly eastward, attended by rough weather to the California coast, which it entered on the 12th. On the 16th to 18th a weak depression lay near 30° N., 135° W., then disappeared. From the 19th to the 23d the gulf LOW extended far southward and caused gales along the northern part of the Hawaiian routes.

In the southeastern Gulf of Alaska the weather was most violent on the 7th and 8th; off the coast of Oregon on the 10th; and over the region bounded by the 35th and 50th parallels, 150th and 165th meridians, west, on the 8th and 24th to 26th. On the 22d, 26th, and 28th winds of force 11 and 12 occurred in east longitudes between the 165th and 180th meridians, 35th and 48th parallels.

The lowest pressure reading of the month occurred near 49° N. and the 180th meridian on the 16th. (See table.) The minimum, 28.03 inches, was read on board the American steamship *President Jackson*, in 49° 14′ N., 178° 36′ W.

The eastern Pacific anticyclone disintegrated considerably from the high state of development it reached in January and held its normal position off the American coast on few days of the month.

Pressure was below normal at apparently all ocean and island points north of and immediately west of Hawaii.

Considering the barometric conditions for February at the island stations of Dutch Harbor, Midway Island, and Honolulu, we find the following: The average 8 p. m. pressure at Dutch Harbor was 29.37 inches, or 0.25 inch below the normal. The extremes were 30.10, on the 8th—the only day in which the barometer read as high as 30 inches—and 28.64, on the 25th. The pressure was above normal on only 10 days, embraced between the 5th and the 20th. Midway Island had an average p. m. pressure of 29.96, or 0.07 below the normal. The extremes were 30.36, on the 7th, and 29.60, on the 16th. Readings above normal occurred on 10 days, and these mostly in the first decade. At Honolulu the average (8 a. m.–8 p. m.) pressure was 30.04, or exactly normal, The highest reading was 30.15, on the 5th; the lowest, 29.86, on the 12th.

NOTES

American schooner *Irene*, Capt. A. E. Rosendal, Grays Harbor, Wash., toward Honolulu:

From January 25, 1925 to February 10. One continuous gale from ESE. to WSW. Heavy rain most of the time, wind blowing hardest from ESE. to SSW. Lowest barometer 29.42, on February 8 at noon. Positions, January 25, 44° 34′ N., 125 ° 34′ W.; February 10, 37° 30′ N., 128° 40′ W.

Swedish steamship *Boren*, Capt. A. Hellman, observer A. T. Eckman, chief officer, Manila toward San Francisco:

Several times at night during heavy hail squalls have the wireless antennæ been illuminated by light of about the same color as water phosphorescence, in some cases only the port wire, but in very heavy hail squalls both wires. The light has sometimes been of fixed strength and sometimes of flaming character. [St. Elmo's Fire.—*W. E. H.*]

DETAILS OF THE WEATHER IN THE UNITED STATES

GENERAL CONDITIONS

By ALFRED J. HENRY

The outstanding feature of the month was the mild temperatures experienced in practically all parts of the country (Chart IV). Naturally there was an absence of general cold waves. This condition was probably due, in great part, to the presence of great barometric depressions centered over the Gulf of Alaska and the northeastern Pacific from which offshoots were discharged at fairly regular intervals throughout the month. There was also an unusual number of secondary cyclonic disturbances which for the most part originated east of the Rocky Mountains in southeastern Wyoming. Some of these moved toward the southeast and then to the northeast and two of them had a short life. Pressure in the North Pacific HIGH was but 30.18 inches; the North Atlantic HIGH was however, well developed on both sides of that ocean. The usual details follow.

CYCLONES AND ANTICYCLONES

By W. P. DAY

The month began with a series of LOWS passing through the Aleutian Islands, the Gulf of Alaska, British Columbia, and along the northern border, a condition continuing until the 9th, when rising pressure over the interior of Alaska and the Canadian Northwest caused a deflection of the LOWS into lower latitudes. The latter condition continued until the end of the month, with generally high pressure over the interior of Canada and a succession of high-pressure areas from that region. However, these moving HIGHS, with the exception of the one which appeared over Alberta on the 25th, did not produce any marked changes to colder. With one or two exceptions the low-pressure areas passing across the United States were not important as storms, but their great frequency associated with the numerous HIGHS caused rapid fluctuations in temperature in north-central districts during the second and third decades of the month.

FREE-AIR SUMMARY

By V. E. JAKL

Free-air temperatures were above normal over all aerological stations, and the departures moreover were generally quite uniform with altitude. (See Table 1). Therefore Chart III, this REVIEW, giving surface departures, represents the free-air departures as well. Pronounced inversion in temperature were not so frequent as in the preceding winter months; yet a few instances of decided inversion were recorded during the first few days. The kite flights at Ellendale furnished an example on the 2d of an inversion that, for steepness of the inverted gradient, probably exceeds, or at any rate equals, any heretofore recorded at that station. On this date, the morning surface-minimum temperature was −28.9° C.; at 900 meters above the ground the temperature at 8 a. m. was 0.4° C., and at 3,900 meters above the ground the temperature at 9:30 a. m. was −13.1° C. The circumstance of pressure, wind direction, etc., inducing this temperature gradient was typical of the conditions attending recovery of temperature after a cold wave, as brought out in the Free-Air Summary for January, 1925.

It was shown in the Free-Air Summary for December, 1924, that cold waves were often observed to begin in the lower levels and then gradually extend to higher altitudes, the building-up process sometimes taking a number of days. On the other hand, the change to colder sometimes seems to occur almost simultaneously above and below, and again a change to decidedly colder aloft may be accompanied by no change or a retarded change in the levels near the ground. Illustrations of a few of the diverse vertical temperature gradients accompanying changes to colder are given in the following extracts from the records of Broken Arrow, and Ellendale, in which each column shows the temperature in the free air after a change to colder from the day before. At Broken Arrow the change on the 2d was most pronounced in the lower levels, and on the 25th in the upper levels, and similarly at Ellendale on the 1st and 26th respectively.

Broken Arrow, Okla. (altitude, 233 meters, m. s. l.)

Feb. 2, 1925			Feb. 25, 1925		
Altitude, m. s. l. (meters)	Temperature	Wind direction	Altitude, m. s. l. (meters)	Temperature	Wind direction
	° C.			° C.	
Surface	−8.0	N.	Surface	6.7	NNW.
668	−11.8	NNE.	519	8.6	NNE.
1,152	2.9	NNE.	975	8.4	N.
3,308	−7.5	NNE.	2,161	−2.7	NNW.
3,807	−4.5	NNE.	2,913	−10.6	NNW.
4,302	−7.6	N.	3,636	−16.4	NW.

Ellendale, N. Dak. (altitude, 444 meters, m. s. l.)

Feb. 1, 1925			Feb. 26, 1925		
Altitude, m. s. l. (meters)	Temperature	Wind direction	Altitude, m. s. l. (meters)	Temperature	Wind direction
	° C.			° C.	
Surface	−22.6	N.	Surface	−21.2	NW.
669	−24.9	N.	1,159	−26.8	NW.
1,817	−17.9	NNW.	1,777	−22.7	NNW.
2,474	−7.9	NW.	2,404	−21.0	NNW.
			2,821	−22.5	NNW.

It is of interest to note to what extent these different types of temperature changes are distinguished by definite types of weather maps. As an approach to an approximate classification, it may be said that when a HIGH is being gradually reinforced, the "building up" process continues until the isobars are closed on the north, after which a change to warmer undoubtedly begins—probably in the upper levels first. If a "closed" HIGH passes over a station, it is a common fact of observation that the lowest temperature will not extend above some moderate altitude, say 1,000 to 2,000 meters. If a well-defined LOW with long isobars in its rear extending far to the north precedes the HIGH, there will be a strong drainage from a northerly direction to a great depth and over considerable territory, and the change to colder will occur simultaneously aloft and below, or more rapidly aloft than below, according to the various characteristics of the HIGH and the position of the place of observation relative to the pressure trough and crest. As the identity of these different types is of course not always well defined, a clue to the vertical temperature gradient may sometimes be had by considering the probable sources of air at the different levels, in connection with the various pressure and temperature features of the surface weather map.

Wind resultants for the month, deduced from kite and pilot-balloon observations, showed a fairly close agreement with the normal, i. e., winds of moderate force varying somewhat between south and west near the ground, but tending steadily to become strong winds from nearly due west in the higher levels. (See Table 2). However, a slight deviation of the resultant wind from normal (less northerly component in the upper

levels and more southerly component in the lower levels) is noted over most stations. This slight deviation does not appear sufficient to account for the general well defined excess of the mean temperature over the normal. This may be ascribed to the comparative infrequency of severe cold waves during the month, and the fact that a rigid comparison between resultant wind directions and mean temperatures is not warranted. The force of this last statement is apparent when it is considered that sometimes a south wind is cold, particularly in the lower levels, when it occurs in the receding phase of cold waves, and that a northwest wind is sometimes warm, particularly in the upper levels, when it occurs in connection with a LOW advancing from the Northwest, and may perhaps be traced back to oceanic origin.

A number of instances of high wind occurred during the last decade, in connection with the passage of well-defined LOWS over the country. Examples of such winds are given in the observations at Ellendale and Memphis on the 26th, of 36 meters per second from the northwest at 4,000 meters altitude, and 35 meters per second from the west-southwest at 2,500 meters altitude, respectively; and at Royal Center on the 27th, of 35 meters per second from the west-northwest at 3,400 meters. In these instances, however, a strong latitudinal temperature gradient undoubtedly contributed toward the observed velocities, inasmuch as in each case cited the observation was made at a time when the station was outside the immediate scope of the low pressure area appearing on the surface map. Instances of high velocity aloft, where the latitudinal temperature gradient seemed to be the predominant factor, occurred frequently toward the end of the middle decade. Examples are taken from the records of the 17th, on which date at Ellendale the wind showed a steady rapid rise from 3 meters per second on the ground to 30 meters per second at 3,800 meters altitude, and at Royal Center a wind of 1 meter per second on the ground gained strength with altitude to 5,200 meters, where a velocity of 34 meters per second was recorded.

The average relative humidity and vapor pressure for the month showed no important differences from the normal at any station. In the records of individual observations some significant features of humidity are shown, of which examples are given in the following table of the observations at Broken Arrow and Groesbeck on the 22d and 28th, respectively. These observations illustrate the effectiveness of source of air in changing the humidity at any particular level.

Broken Arrow, Okla. (altitude, 233 meters), February 22, 1925

Time	Altitude, m. s. l. (meters)	Temperature	Relative humidity	Wind direction
		°C.	Per cent	
7:57 a. m.	Surface	13.0	97	S.
8:36 a. m.	1,553	9.6	58	SSW.
9:17 a. m.	2,425	−0.4	91	SSW.
10:02 a. m.	2,470	1.0	34	W.
10:16 a. m.	1,328	11.8	57	SSW.
13:45 a. m.	Surface	16.0	79	S.

Groesbeck, Tex. (altitude, 141 meters), February 28, 1925

Time	Altitude, m. s. l. (meters)	Temperature	Relative humidity	Wind direction
		°C.	Per cent	
2:09 p. m.	Surface	14.5	62	SSW.
2:33 p. m.	1,119	8.1	92	S.
2:54 p. m.	1,942	6.7	21	SW.
4:09 p. m.	4,450	−4.0	12	WSW.
4:59 p. m.	2,177	5.6	12	WSW.
5:21 p. m.	1,047	13.6	16	S.
5:34 p. m.	Surface	16.8	59	SSW.

It will be noted that at Broken Arrow between 2,400 and 2,500 meters the temperature rose and humidity fell, attending a change in direction from south to west from 9:17 a. m. to 10:02 a. m. As the change in humidity is much too large to be accounted for by a mere change in temperature due to adiabatic or insolation causes, the change must necessarily have been of an advectional nature. Similarly, at Groesbeck the change at about 1,100 meters from 92 per cent at 2:33 p. m. to 16 per cent at 5:21 p. m. can be accounted for in no other way, as the accompanying rise in temperature was inadequate of itself to cause the observed fall in humidity. The record of Groesbeck, moreover, proves that such rapid changes in humidity are not necessarily brought about by changes in wind direction, as the wind remained due south at the level in question throughout the observation.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during February, 1925*

TEMPERATURE (°C)

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233 m.)		Drexel, Nebr. (396 m.)		Due West, S. C. (217 m.)		Ellendale, N. Dak. (444 m.)		Groesbeck, Tex. (141 m.)		Royal Center, Ind. (225 m.)	
	Mean	Departure from 7-yr. mean	Mean	Departure from 10-yr. mean	Mean	Departure from 4-yr. mean	Mean	Departure from 8-yr. mean	Mean	Departure from 7-yr. mean	Mean	Departure from 7-yr. mean
Surface	5.5	+0.4	−2.0	+1.9	8.9	+0.4	−7.6	+2.5	13.1	+2.9	0.9	+2.7
250	5.5	+0.5	------	------	8.7	+0.4	------	------	12.6	+2.8	0.7	+2.7
500	5.0	+1.3	−2.1	+2.2	7.1	+0.2	−7.7	+2.4	11.7	+2.9	−0.9	+2.9
750	4.6	+1.8	−1.5	+3.1	6.4	+0.4	−7.7	+2.0	11.5	+3.0	−1.5	+3.0
1,000	4.9	+2.4	0.3	+4.2	5.5	+0.2	−6.9	+2.2	11.5	+3.2	−1.5	+3.3
1,250	4.7	+2.4	0.8	+4.1	4.6	+0.2	−6.4	+2.2	10.8	+3.1	−1.9	+3.4
1,500	4.3	+2.6	0.4	+3.8	3.7	+0.2	−6.4	+2.1	10.0	+3.0	−2.4	+3.3
2,000	1.9	+1.7	−1.5	+3.1	1.4	−0.5	−7.2	+2.5	7.6	+2.8	−3.9	+2.9
2,500	−1.0	+1.1	−3.9	+2.8	−0.7	−0.1	−9.9	+1.9	5.0	+2.2	−6.4	+2.1
3,000	−4.3	+0.5	−6.8	+2.4	−2.7	+0.1	−12.8	+1.6	2.3	+1.9	−9.4	+1.5
3,500	−7.3	+0.1	−9.6	+2.3	−5.8	−0.2	−15.8	+1.3	−0.8	+1.3	−13.2	+0.5
4,000	−9.9	+0.1	−13.4	+1.4	−7.7	+0.8	−18.6	+1.1	−3.6	+0.9	−17.8	−1.0
4,500	−13.4	−0.3	−16.6	+1.4	------	------	−21.5	+0.9	------	------	------	------
5,000	------	------	−19.8	+1.8	------	------	−24.5	+0.8	------	------	------	------

RELATIVE HUMIDITY (%)

Surface	70	+3	79	+2	67	−1	81	0	64	−10	78	0
250	70	+3	------	------	66	−2	------	------	63	−9	78	0
500	64	0	76	+1	62	−3	80	0	61	−8	77	−1
750	58	−3	66	−4	59	−5	75	+1	55	−10	74	−1
1,000	50	−6	55	−9	56	−7	69	−1	47	−13	68	−2
1,250	44	−8	50	−10	54	−8	65	−1	43	−14	62	−4
1,500	42	−8	48	−9	53	−7	62	0	39	−14	57	−5
2,000	37	−9	48	−5	53	−4	58	−1	35	−13	55	−2
2,500	36	−9	48	−4	49	−7	58	−1	36	−9	55	0
3,000	36	−6	50	−2	46	−7	58	0	37	−7	59	+3
3,500	37	−4	50	−2	50	−3	55	−1	38	−4	65	+8
4,000	36	−5	49	−1	74	+13	55	0	38	0	82	+23
4,500	38	−3	49	−1	------	------	57	+2	------	------	------	------
5,000	------	------	46	−4	------	------	60	+2	------	------	------	------

VAPOR PRESSURE (*mb.*)

Surface	6.65	+0.50	4.37	+0.56	8.15	+0.06	3.07	+0.51	9.97	+0.28	5.61	+1.17
250	6.59	+0.49	------	------	7.97	+0.01	------	------	9.54	+0.31	5.53	+1.16
500	5.65	+0.28	4.17	+0.55	6.73	−0.38	3.03	+0.51	8.71	+0.42	5.02	+1.17
750	4.98	+0.24	3.73	+0.45	6.08	−0.54	2.75	+0.40	7.72	+0.15	4.69	+1.19
1,000	4.34	+0.09	3.32	+0.23	5.54	−0.73	2.67	+0.38	6.45	−0.35	4.19	+0.99
1,250	3.71	−0.13	3.08	+0.13	4.91	−0.87	2.62	+0.40	5.63	−0.49	3.65	+0.81
1,500	3.36	−0.12	2.91	+0.17	4.45	−0.83	2.50	+0.42	4.78	−0.54	3.19	+0.66
2,000	2.49	−0.29	2.50	+0.19	3.70	−0.56	2.13	+0.37	3.74	−0.35	2.46	+0.43
2,500	1.96	−0.35	2.15	+0.23	2.94	−0.51	1.72	+0.25	3.26	−0.05	1.74	+0.07
3,000	1.58	−0.26	1.83	+0.25	2.48	+0.27	1.30	+0.16	2.86	+0.05	1.39	+0.03
3,500	1.29	−0.19	1.50	+0.23	2.20	−0.18	0.95	+0.09	2.54	+0.21	0.95	−0.07
4,000	1.09	−0.09	1.18	+0.21	2.69	+0.53	0.67	−0.01	2.47	+0.61	0.82	+0.07
4,500	0.88	−0.03	1.03	+0.22	------	------	0.51	−0.03	------	------	------	------
5,000	------	------	0.89	+0.16	------	------	0.37	−0.02	------	------	------	------

TABLE 2.—*Free-air resultant winds (m. p. s.) during February, 1925*

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233 m.)				Drexel, Nebr. (396 m.)				Due West, S. C. (217 m.)				Ellendale, N. Dak. (444 m.)				Groesbeck, Tex. (141 m.)				Royal Center, Ind. (225 m.)			
	Mean		7-year mean		Mean		10-year mean		Mean		4-year mean		Mean		8-year mean		Mean		7-year mean		Mean		7-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 81°E.	0.9	N. 20°W.	0.6	S. 55°W.	0.7	N. 67°W.	1.3	S. 81°W.	1.5	S. 89°W.	1.6	N. 43°W.	3.1	N. 43°W.	3.6	S. 36°W.	3.2	N. 76°W.	0.4	S. 50°W.	1.7	S. 81°W.	2.0
250	S. 74°E.	0.9	N. 24°W.	0.5					S. 83°W.	1.4	N. 89°W.	1.7					S. 40°W.	3.7	S. 68°W.	0.5	S. 50°W.	2.0	S. 77°W.	2.3
500	S. 17°E.	1.7	S. 85°W.	0.5	S. 63°W.	1.3	N. 74°W.	1.9	S. 80°W.	2.7	S. 87°W.	3.0	N. 49°W.	3.3	N. 48°W.	3.8	S. 42°W.	4.6	S. 42°W.	1.3	S. 48°W.	5.1	S. 66°W.	3.8
750	S. 41°W.	2.1	S. 63°W.	1.6	S. 84°W.	2.9	N. 71°W.	4.0	S. 79°W.	2.9	S. 80°W.	4.2	N. 61°W.	4.0	N. 55°W.	4.7	S. 53°W.	5.0	S. 51°W.	2.1	S. 58°W.	6.9	S. 68°W.	5.5
1,000	S. 70°W.	1.9	S. 70°W.	2.4	N. 83°W.	4.1	N. 66°W.	5.1	S. 86°W.	3.6	S. 80°W.	5.3	N. 64°W.	5.0	N. 43°W.	5.2	S. 63°W.	5.5	S. 63°W.	3.3	S. 65°W.	8.1	S. 73°W.	6.8
1,250	S. 82°W.	3.1	N. 88°W.	3.5	N. 84°W.	5.3	N. 66°W.	6.5	S. 84°W.	4.6	S. 81°W.	6.7	N. 68°W.	6.3	N. 55°W.	6.3	S. 77°W.	5.8	S. 74°W.	4.3	S. 67°W.	8.6	S. 81°W.	7.8
1,500	N. 85°W.	3.9	N. 81°W.	4.3	N. 78°W.	6.1	N. 66°W.	8.1	S. 88°W.	6.4	S. 84°W.	8.6	N. 71°W.	7.2	N. 59°W.	7.4	S. 84°W.	6.4	S. 80°W.	5.7	S. 75°W.	10.3	S. 86°W.	9.3
2,000	N. 86°W.	6.4	N. 77°W.	6.5	N. 81°W.	10.0	N. 69°W.	10.4	S. 84°W.	8.7	S. 86°W.	11.9	N. 68°W.	10.6	N. 62°W.	9.6	N. 85°W.	6.6	S. 86°W.	7.3	S. 77°W.	13.2	S. 89°W.	11.3
2,500	N. 88°W.	7.4	N. 76°W.	7.4	N. 87°W.	12.8	N. 70°W.	12.7	S. 67°W.	8.4	S. 83°W.	13.4	N. 67°W.	12.4	N. 64°W.	11.7	S. 76°W.	8.2	S. 88°W.	8.5	S. 64°W.	16.2	W.	13.7
3,000	N. 72°W.	6.5	N. 78°W.	9.7	N. 87°W.	14.3	N. 75°W.	14.4	S. 74°W.	10.2	S. 85°W.	15.4	N. 73°W.	13.7	N. 66°W.	13.0	S. 72°W.	9.8	S. 87°W.	10.4	S. 60°W.	17.3	S. 89°W.	14.6
3,500	N. 66°W.	10.0	N. 65°W.	10.7	N. 87°W.	15.4	N. 74°W.	15.8	N. 64°W.	10.3	N. 82°W.	16.3	N. 70°W.	15.4	N. 69°W.	12.9	S. 75°W.	10.6	N. 89°W.	11.2	S. 63°W.	17.0	N. 88°W.	17.2
4,000	N. 84°W.	12.5	N. 69°W.	10.7	S. 81°W.	16.1	N. 80°W.	15.9	N. 66°W.	12.0	N. 85°W.	11.6	N. 70°W.	17.1	N. 66°W.	14.1	S. 57°W.	17.2	N. 89°W.	12.3	S. 38°W.	17.7	S. 88°W.	16.2
4,500	S. 86°W.	12.5	N. 61°W.	11.9	S. 89°W.	21.5	N. 84°W.	17.6	----------	----	----------	----	N. 75°W.	20.2	N. 66°W.	15.4	S. 67°W.	18.0	N. 79°W.	12.8	S. 45°W.	20.9	W.	16.9
5,000	S. 87°W.	13.4	S. 74°W.	12.1	W.	20.0	N. 83°W.	16.8	----------	----	----------	----	N. 45°W.	17.0	N. 87°W.	17.2	----------	----	----------	----	----------	----	----------	----

THE WEATHER ELEMENTS

By P. C. DAY, In Charge of Division

PRESSURE AND WINDS

The first few days of February, 1925, brought important pressure variations and consequently sharp changes in temperature, particularly along the northern boundary and over the southern districts of Canada, where locally the lowest and highest temperatures of the month were recorded within 24 hours, the changes amounting to as much as 60° within the same period.

Immediately following, however, pressure assumed a more stable condition and weather changes were less marked until the beginning of the second decade, when cyclonic conditions overspread the districts from the Mississippi River eastward, attended by considerable rain or snow. This was immediately followed by an anticyclone which, though not producing marked low temperatures over northern districts, nevertheless favored an extension of freezing temperatures into the Southeastern States and notably over the Florida Peninsula, where on the 12th and 13th they occurred over the greater part of the State, though they continued for too short a period to cause serious damage save to the more tender forms of vegetation.

During the latter half of the month no important cyclones or anticyclones crossed the country until early in the last decade, when a cyclonic area that first appeared over the far southwest on the 21st attained considerable proportions by the morning of the 23d. At this time it covered an extensive area from the middle Mississippi Valley northeastward to the lower Lakes, and precipitation, mostly rain, had occurred over a wide area from the Great Plains eastward to the Appalachian Mountains, with local heavy falls in portions of the Mississippi and Ohio Valleys. During the following 24 hours the storm moved rapidly northeastward, attended by rains over most eastern districts, though the falls were mainly unimportant.

During the last few days of the month a cyclonic area moved eastward along the northern border from Montana to New England, becoming of considerable importance over the Great Lakes and thence to New England on the 26th and 27th. The precipitation attending this storm was mostly in the form of snow, some heavy falls being reported on the Canadian side of the border. High winds accompanied this storm from the lower lakes eastward to the coast, and considerably colder weather with high barometric pressure followed.

Anticyclones were mainly of far less importance than those usually experienced during a winter month. Those materially influencing the temperature over considerable areas were as follows: From the 1st to 3d, along the northern border from the Rocky Mountains eastward, that of the 11th to 13th bringing decidedly cold weather over the Southeastern States; and another near the end of the month that brought sharp falls in temperature from the northern Rocky Mountains eastward to New England.

In the far Western States moderate cyclonic conditions persisted during the first decade but were principally confined to the more northern districts. The second decade was comparatively free from storms of any character. The first half of the third decade had moderately unsettled, stormy weather over the northern districts, but the closing days were under the influence of an anticyclone of material strength.

The pressure distribution for the month as a whole was distinctly favorable for warm and dry conditions in most parts of the country. The barometric gradient was mainly toward the north, the anticyclones tending toward the southern section, while the cyclones frequently moved eastward along the northern boundary.

The average pressure was well below normal over all parts of the country save over the southwest and extreme northeast sections, and it was distinctly below in the central and far northwestern districts, thus favoring prevailing southerly winds over the greater part of the country. These were particularly noticeable in the western districts, where, on account of local topography, there is usually great diversity in the directions of the prevailing winds, while during the month under discussion they were remarkably constant from southerly points.

High winds were infrequent, and over the Atlantic coast districts and the Great Lakes they were mainly confined to the cyclone of the 26th and 27th. No important areas over the interior and southern portions of the country were affected by high winds, and some stations reported the lowest wind movement of record for February.

TEMPERATURE

The chief feature of the weather for February, 1925, is the uniformly high temperature that prevailed over all portions of the United States, and Canada also, as far as observations disclose.

An examination of the temperature data for February during the past 50 years does not disclose a single case where the monthly means of temperature were above normal for all portions of both countries, the reference to Canada of course covering only the southern portions, as no weather-reporting stations with records now available are located in other parts of that country.

The nearest approach to the conditions that existed during February, 1925, was in 1921, when February mean temperatures were above normal in all parts of the United

States and over western and central Canada, but extreme eastern Canada had means slightly below normal. The month stands out prominently also as having in many cases the highest mean temperatures ever observed in February, and in other cases as having the highest individual temperatures ever reported in that month.

The uniformity of the temperature conditions is well illustrated in the fact that the daily means were above the normal each day of the month in several widely separated areas, while many others had only a day or two with temperatures below normal.

The departures of the mean temperature from the normal are graphically shown on Chart III.

The warmest periods of the month were not identical over extensive areas; in fact, the warmest dates ranged at intervals from the first to the 28th, though the principal dates were the 6th to 9th from the Missouri Valley eastward; about the 21st to 23d from Texas and Oklahoma eastward, and in some of the western Mountain States; and on the 28th in Arizona and Oregon.

The lowest temperatures were observed mainly from the 2d to 4th over the middle and northern Great Plains and thence eastward to the North Atlantic States; from the 8th to 11th in the western Mountain States; from the 11th to 13th over the East Gulf and South Atlantic States; and on the 27th and 28th over a considerable area from the Southern Plains northeastward to the Great Lakes and locally along the north Atlantic coast.

The lowest temperature observed during the month, 42° below zero, occurred in Minnesota, and temperatures below freezing occurred in all portions save the coast districts and southern portions of Florida, extreme southern Texas, and over the lower elevations and coast districts of Arizona and California. No important damage from frosts or freezing occurred, however, except in Florida and portions of nearby States, where tender vegetation was injured to some extent.

PRECIPITATION

While the precipitation over most sections of the country was sufficient for present needs, nevertheless the month as a whole was remarkably dry, and particularly so in the southern portions.

Over the Pacific coast States from central California northward the precipitation was mainly above normal, and was unusually heavy in some central coast and northern sections of California. In all other portions of the country, save in a few small areas, the precipitation was less than is usually received in the last winter month. From Texas eastward and northeastward to the Atlantic coast the deficiency ranged from 2 to nearly 4 inches, though on account of the heavy rains during the preceding month no serious drain upon the moisture supply resulted. Over the districts from the central portions of Oklahoma and Texas westward to southern California the drought of previous months continued and great need for more rain was being felt. In portions of New Mexico the lack of sufficient moisture has continued for more than a year, and in Arizona and southern California the water supply continues inadequate.

SNOWFALL

The month was one of light snowfall in practically all parts of the country, and the depths on ground at various times during the month and at the end were mainly less than normal, in fact over large areas in the central valleys and eastern districts the total fall was the least ever known in February. The amounts in the western mountains were also very generally less than usually falls.

At the end of the month material depths were confined to northern New England, the Lake Superior region and thence westward to North Dakota, and the higher elevations of the western mountains. The outlook at the end of the month for a satisfactory supply of water for the dry season in the Western States dependent upon the stored snowfall in the mountains, continues mainly satisfactory over the Northern and portions of the Central States, but remains fair or poor to unsatisfactory to the southward.

HUMIDITY AND SUNSHINE

The lack of precipitation during the month was reflected in the average relative humidity, which was mainly below normal from the Mississippi River westward, and largely so from Louisiana and Texas northwestward over the Great Plains, Rocky Mountain and Plateau districts to the Canadian boundary. East of the Mississippi River the averages above and below normal were about equally divided, though apparently not materially influenced by the distribution of precipitation.

The month as a whole had much clear weather over the central and southern districts, and in practically all districts sunshine was probably more abundant than is usually the case for a winter month.

SEVERE LOCAL HAIL AND WIND STORMS, FEBRUARY, 1925

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Troup, Tex.	1					Moderate hail	Considerable damage reported	Official, U. S. Weather Bureau.
Butte, Mont. (near)	6	A. m.				High wind	Buildings damaged; fences blown down	Do.
Mulberry, Ark.	8	9 a. m.	150		$20,000	Small tornado	Details of damage not reported	Do.
Cairo, Ill.	8					Thunderstorm	Power house of traction company struck by lightning; all light and power service suspended.	Do.
Settle, N. C.	11	9-10:30 a.m.				Heavy hail	Character and amount of damage not reported	Do.
Baton Rouge, La. (3 miles north of).	16					do	Minor damage resulted	Do.
Castalian Springs, Tenn. (near).	16				5,000	Thunderstorm	Barn and contents destroyed by lightning	Do.
Pooleville, Okla.	21	9 a. m.	100		60,000	Tornado	One person injured. Greater part of damage in oil fields.	Do.
Loco, Okla.	21	7:30 p. m.		1		do	Five persons injured. Several homes and other small buildings completely demolished.	Do.
Henryetta, Okla.	21	11:15 p. m.	66		15,000	do	Two persons injured; some property loss	Do.
Northern California.	22					High winds	Communication and power lines damaged	Do.
San Francisco Bay, Calif.	22					do	Small craft damaged	Do.
Dallas, Tex., and vicinity.	22	12:22 a. m.				Thunderstorm	Considerable property damage; 5 persons injured.	Do.
Crescent City, Calif.	23	A. m.				Violent wind	Several buildings wrecked	Do.
Charlotte, Tenn. (near)	23					Wind	One home razed; other property damage; 2 persons injured.	Do.

STORMS AND WEATHER WARNINGS

WASHINGTON FORECAST DISTRICT

There were no gales along the Atlantic or east Gulf coasts during the first 10 days of the month, although storm warnings were issued for the region from Sandy Hook, N. J., to the Virginia Capes on the 2d. On the morning of the 11th a disturbance was central over West Virginia and moving east-northeastward with increasing intensity. Anticipating a further increase in both intensity and extent, storm warnings were ordered displayed from Jacksonville, Fla., to Eastport, Me. This storm was attended by west and northwest gales from Cape Hatteras to Cape Cod, the highest velocity reported being 46 miles an hour from the northwest at Cape Henry, Va.

The next warnings were issued for the north Atlantic coast from Sandy Hook, N. J., to Eastport, Me., in connection with a disturbance that moved rapidly down the St. Lawrence Valley. However, the only wind of gale force reported was 38 miles from the southwest at Eastport, Me. Again, on the morning of the 23d warnings were displayed from Delaware Breakwater to Eastport, Me., because of the rapid advance of a disturbance of considerable intensity that at that time was central over western Lake Erie. This disturbance diminished in intensity, however, during the day, and no winds of gale force were reported.

By far the most severe storm of the month was that of the 26th in the Northeastern States. This disturbance moved eastward along the northern border with gradually increasing intensity until the morning of the 26th, when it was centered over southwestern Quebec. At this time, a secondary was developing over southern New York, and it moved rapidly northeastward, gaining great strength during the day, and at 8 p. m. was centered near Eastport, Me., where the barometer read 28.84 inches. Westerly gales prevailed throughout the lower Lake region, upper Ohio Valley, and in the Middle Atlantic and North Atlantic States. The highest wind velocity reported was 72 miles an hour from the west at Buffalo and New York City. Northwest storm warnings were displayed from Cape Hatteras to Cape Cod at 9 a. m. and north of Cape Cod to Eastport at noon of the 26th. No strong winds occurred before the passage of the storm center, inasmuch as the pressure gradient to the eastward was slight.

There were no general cold waves during February and only three of quite limited extent. The first of these was in the northern portions of Maine, New Hampshire, and Vermont during the 1st–2d; the second was in the southern Appalachian region during the 11th–12th; and the last in northern New England and northern and central New York during the 26th–27th. Cold-wave warnings were issued on the 1st and 26th, but not on the 11th.

Frost warnings were issued for extreme northwestern Florida and the southern portions of Alabama and Mississippi on the 2d, 3d, 11th, 12th, 17th, and 26th, and for southern Georgia and all or part of northern Florida on the 3d, 11th, 12th, 18th, and 26th. The warnings were extended to central Florida on the 11th and to Miami on the 12th. The most important warnings were those of the 11th and 12th. Heavy to killing frost and freezing temperature occurred as far south as extreme northern Florida on the 12th, and to Orlando, Fla., on the 13th.—*C. L. Mitchell.*

CHICAGO FORECAST DISTRICT

With respect to comparative freedom from severe weather conditions, the month of February, 1925, in the Chicago Forecast District resembled its immediate predecessor, January. Furthermore, most of the month was unusually mild and dry, this being especially true in northwestern sections. Only one cold wave of consequence occurred, and, likewise, only one storm that could be classed as at all severe, visited Lake Michigan, where more or less navigation goes on throughout the winter.

Cold-wave warnings.—Cold-wave warnings were issued on but three days, namely, the 15th, 25th, and 28th. The first and last mentioned were for limited areas in the northwestern portion of the district, while that on the 25th embraced a considerable area in the middle Missouri and extreme upper Mississippi Valleys and Upper Lake Region. In most cases the cold waves occurred as forecast, but the warnings should have been extended over additional territory in some instances. At the very close of the month a new cold wave was about to sweep southward over the district.

Storms on Lake Michigan.—Several low-pressure areas crossed the Great Lakes region during the month, but only one disturbance attained the proportions of a storm. Advisory warnings were issued on the 1st, 8th, 18th, 20th, 22d, 24th, 25th, and 26th. The storm of the 25th–26th was rather severe. Not only did it increase greatly in intensity as it reached the Lake Region from the far Northwest, but conditions were accentuated because of the presence of a marked area of high pressure in its rear. West and northwest gales occurred in this connection over most of the lake.

Livestock warnings.—It was not necessary to issue any special advices for the benefit of livestock interests, and no inimical weather conditions are known to have occurred.

Special forecasts.—A special forecast as to temperature and snowfall was made for the benefit of the U. S. Army Air Service in connection with their winter maneuvers in Michigan near the middle of the month, and we learn that this proved to be of considerable assistance.—*C. A. Donnel.*

NEW ORLEANS FORECAST DISTRICT

Moderate conditions prevailed, without severe cold waves or storms. The only storm warnings were issued on indications of the p. m. map of the 26th, when a moderate depression over West Texas was advancing southeastward and a fairly steep barometric gradient extended to an area of high pressure over the Missouri Valley; northwest storm warnings were issued for the Texas coast but the winds did not reach verifying velocity. Small-craft warnings were displayed on the east coast of Texas on the 2d and on the Louisiana coast on the 27th.

Warnings for moderate cold waves were issued on the 1st for the northern portion of the district, on the 2d for Port Arthur and Houston, Tex., and on the 10th and 16th for the northwestern portion of the district except the north portion of west Texas. These warnings were mostly verified. Warnings issued on the morning of the 25th for a moderate cold wave in the northern portion of the district and at night on the 26th for Arkansas, East Texas, and the southeastern portion of West Texas, failed of verification in most parts of the areas named, the change to

colder being gradual in Oklahoma and mostly insufficient for a cold wave in East Texas. Warnings for livestock were included in most cold wave warnings.

Frost warnings for coast sections were issued on the 2d, 3d, 10th, 11th, 12th, and 17th, and were generally verified.—*R. A. Dyke.*

DENVER FORECAST DISTRICT

February was an unusually mild and dry month over the entire Denver district. While a number of LOWS of unusual intensity appeared during the first 12 days and again during the last week of the month over the Pacific Northwest, most of them moved eastward over the northern track without the usual development of secondary disturbances on the plateau, so common in the winter months. Most of the Canadian high-pressure areas passed eastward without affecting this district, except one that was drawn southward on the 25th and 26th by a LOW that moved directly southward from eastern Colorado into New Mexico, causing light precipitation in eastern Colorado on the night of the 26th. Precipitation occurred in Utah and western Colorado on the 6th–7th, attending a secondary LOW that developed over northern Arizona on the 6th and moved eastward across northern New Mexico. Another secondary developed over southern Nevada on the 20th and moved eastward across Utah and Colorado, attended by precipitation in the northwestern part of the district on the 20th and 21st.

On the morning of the 10th, with a LOW moving rapidly eastward across southern Missouri and a strong high-pressure area advancing southeastward from southern Idaho, warning was issued for a moderate cold wave in southeastern New Mexico, which occurred as predicted.—*E. B. Gittings, jr.*

SAN FRANCISCO FORECAST DISTRICT

There were two well marked storm periods in this district during the month. The first covered the first decade and the second the greater portion of the third decade and was mostly confined to the North Pacific States. Generous precipitation fell from central California and central Nevada northward with a fairly good amount of snow in the mountains. In southern California and southern Nevada the drought continued with but little abatement. In northern California the seasonal rainfall at the close of the month amounted to over 90 per cent of normal, while in southern California it was only slightly over 30 per cent.

The month opened with two large storm systems covering the north Pacific; (a) central about latitude 55 degrees north and longitude 140 degrees west, and (b) in latitude 45 degrees north and longitude 170 degrees east. These storms while closely following one another, maintained their individuality, and passed inland in series of small storms with greatly diminished intensity; the last of which entered the continent on the 12th. On the 6th, a large area of high pressure appeared over Midway Island and extended rapidly north and east following the storm (b). On the 9th, the area of high pressure was central in latitude 35 degrees north, and longitude 165 degrees west, with a ridge extending northward over central Alaska. At this time another storm (c) appeared over Bering Sea, and the storm (b) was central in latitude 41 degrees north and longitude 138 degrees west and had reached its maximum intensity. The motor-ship *Aorangi* passing near its center reported a barometer reading of 28.62 inches and a gale of 70 miles per hour. This storm passed inland on the 12th, with greatly diminished intensity and a minimum barometer reading of 29.68 inches.

From the 13th, until the 19th, the Pacific area of high pressure dominated the weather in this district, and fair and pleasant weather prevailed. On the evening of the 19th the storm (c), which first appeared in Bering Sea on the 9th, began to affect the weather on the northern coast, and by the evening of the 20th it had caused precipitation over the entire district, which continued with slight intermittence over the northern and central portions until the 25th. On the 23d an area of high pressure off the southern California coast moved rapidly northeastward and increased greatly in intensity as it neared the coast. By the 24th it had covered the entire Pacific slope and adjacent ocean and gave fair and warm weather after the 25th, except for light rain in the North Pacific States on the 27th.—*G. H. Willson.*

RIVERS AND FLOODS

By H. C. FRANKENFIELD

Reference to the table at the end of this report will show that, with the exception of the flood in the Sacramento River of California, the floods of February, 1925, were not of severe character, and while they were quite numerous and widely scattered, none occurred in the great rivers of the country. Neither were there any in the South Atlantic States, except the aftermath of the great floods of January.

The floods in the Connecticut, Susquehanna, and Hudson Rivers were caused by the melting of quite deep snows attended by some rains and by the formation and subsequent breaking up of ice gorges.

The floods in the Sacramento River and its tributaries were of more decided character. The following general description was summarized from the comprehensive report of Mr. N. R. Taylor, the official in charge of the Weather Bureau office at Sacramento:

On the morning of February 5, 1925, general rains were in progress throughout the drainage basin of the Sacramento Valley, and on that night torrential rains occurred from the foothills to the highest altitudes of the Sierras, melting some of the snow that had accumulated above the 6,000-foot level. By the morning of the 6th all mountain streams were running bank full; the American River at Folsom and thence well up into its forks was higher than at any time since the big floods of 1909, and the Sacramento River at Sacramento had risen to a stage of 26 feet and was still going up. * * *

By early forenoon of the 6th the situation in Sacramento was becoming serious in that the water of the Sacramento River was backing up to the north of the mouth of the American River into the lower portions of North Sacramento, which was rapidly becoming flooded. Early in the afternoon of this date a small levee near the Southern Pacific Railroad bridge broke and increased the spread of the water, which finally occupied some two square miles or so of territory. At about 11:45 a. m. of the 6th some 20 units of the 48 units which comprise the Sacramento by-pass were opened, which deflected about a 4-foot head of water from the Sacramento River, some 3 miles above the mouth of the American, into Yolo Basin, and in the meanwhile, a considerable amount of water was pouring through Fremont Weir, which also leads into Yolo Basin. * * *

At about 1 p. m. of the 7th the river at Bensons Ferry crested at 12.9 feet, 0.1 foot below the stage predicted, but even before reaching this point a number of levees, which had been damaged by beavers, broke and some 2,000 acres of land were flooded in the lower reaches of the Mokelumne and Cosumnes Rivers. * * *

By the morning of February 7 the Sacramento River at Colusa had crested at a stage of 22 feet and by 8 a. m. of the 9th a stage of 17.9 feet, 0.1 foot below the flood stage which was predicted, was recorded at Knights Landing. After the 8th there was a slow but steady fall in all streams.

On the night of February 10, 1925, or about the time the rivers had subsided to safe stages, unusually heavy rains began falling

in the Sacramento Valley from Meridian well up into the Sacramento Canyon, and by the morning of the 11th the Sacramento River was rapidly rising throughout its upper reaches. * * *

The river at Red Bluff crested at a stage of 26.7 feet at about 8 p. m. of the 11th, when it overtopped its banks, flooding a considerable area and drowning a number of cattle the owners of which failed to heed the warnings.

It had been anticipated that the flood would also extend into the lower San Joaquin River, but it did not materialize, as the rains that had been indicated did not occur north of the drainage area of the Stanislaus River, with the result that the lower San Joaquin, which was already at low stage, took ample care of all the water from the lower tributaries.

The flood in the Willamette River of Oregon, so far as its causation was concerned, was a departure from the usual winter rule and was thus commented upon by Mr. E. L. Wells, the official in charge of the Weather Bureau office at Portland:

> Most winter floods in the Willamette River are the result of very heavy warm rains for two or three days, occurring when the soil is already well filled with moisture, and they are sometimes aggravated by a considerable snow cover, which is melted by the warm rains. In the present instance no extremely heavy daily rainfall occurred, and the amount of run-off from melting snow was not great. The flood was the result of a period of five or six weeks [beginning about December 27, 1924] of almost daily precipitation over the entire drainage basin, and, to a small degree, the result of rising water in the Columbia.

All of the floods that occurred during the month were forecast with the usual degree of accuracy. As stated before, none was of very severe character and the loss and damage were not great. The few estimates received include $10,000 in the Connecticut River drainage area, $73,500 in the Sacramento drainage area, and $57,650 in the Willamette drainage area, a total of $141,150. As an offset to these losses the savings through Weather Bureau warnings were reported as having been $80,000 in the Sacramento area and $206,050 in the Willamette area, a total of $286,050. These latter figures were apparently much underestimated, as the official in charge at Portland stated that the amount saved in the Willamette area was several times that reported, as the reports were not nearly complete, and many informants while stating that they were saved from all loss, failed to give any estimate of the value of the property saved.

A belated report stated that the losses in the Waccamaw drainage area of South Carolina during the flood of January, 1925, were about $150,000.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC DRAINAGE					
Connecticut:	*Feet*			*Feet*	
White River Junction, Vt.	15	12	13	18.9	12
Hartford, Conn.	16	14	15	16.2	14
Hudson:					
Troy, N. Y.	15	12	13	15.8	12
Albany, N. Y.	12	12	13	13.1	13
Castleton, N. Y.	10	13	14	11.8	13
Mohawk:					
Utica, N. Y.	11	12	12	11.2	12
		24	24	12.6	24
Schuylkill:					
Reading, Pa.	10	12	12	14.8	12
ATLANTIC DRAINAGE—continued					
Susquehanna:	*Feet*			*Feet*	
Oneonta, N. Y.	12	12	13	15.1	12
		25	25	12.4	25
Bainbridge, N. Y.	11	11	12	14.8	12
Binghamton, N. Y.	14	12	13	17.2	12
Towanda, Pa.	16	12	13	18.7	12
Wilkes-Barre, Pa.	20	12	14	25.0	13
Harrisburg, Pa.	17	12	13	18.8	13
Unadilla:					
New Berlin, N. Y.	8	12	13	12.0	12
		24	25	9.6	24
Neuse:					
Smithfield, N. C.	14	13	14	15.0	13
Waccamaw:					
Conway, S. C.	7	(1)	8	9.3	Jan. 30, 31
Peedee:					
Mars Bluff, S. C.	17	15	15	17.0	15
Santee:					
Rimini, S. C.	12	(1)	23	23.8	Jan. 23
		26	28	12.2	27
Ferguson, S. C.	12	(1)	28	17.1	Jan. 24
Ocmulgee:					
Abbeville, Ga.	11	(1)	1	20.3	Jan. 23
Lumber City, Ga.	15	(1)	1	26.0	Jan. 21
EAST GULF DRAINAGE					
Apalachicola:					
River Junction, Fla.	15	(1)	4	32.1	Jan. 24
Blountstown, Fla.	20	(1)	[3] 6	27.9	Jan. 27
Flint:					
Bainbridge, Ga.	25	(1)	(2)	[3] 39.6	Jan. 24
West Pearl:					
Pearl River, La.	13	(1)	9	17.1	Jan. 21
		21	24	13.7	23
GREAT LAKES DRAINAGE					
St. Joseph:					
Montpelier, Ohio	10	10	11	10.5	10
		25	25	10.6	25
MISSISSIPPI DRAINAGE					
Allegheny:					
Freeport, Pa.	22	12	12	22.0	12
Shenango:					
Sharon, Pa.	9	10	12	10.9	11
Tuscarawas:					
Gnadenhutten, Ohio	9	10	13	10.3	11
		24	26	11.6	25
Green:					
Lock No. 4, Woodbury, Ky.	33	23	27	37.3	25
Lock No. 2, Rumsey, Ky.	34	25	(4)	36.4	28
Wabash:					
Lafayette, Ind.	11	24	26	13.1	25
Illinois:					
Peru, Ill.	14	9	17	15.3	10
		24	(4)	15.3	25
Henry, Ill.	7	9	(4)	8.8	13, 14, 27
Havana, Ill.	14	11	13	14.2	12
Beardstown, Ill.	12	7	(4)	14.3	13 to 16
North Platte:					
North Platte, Nebr.	5	4	13	5.6	6
Grand:					
Gallatin, Mo.	20	24	25	26.5	25
Chillicothe, Mo.	18	24	26	20.6	25
PACIFIC DRAINAGE					
Sacramento:					
Red Bluff, Calif.	23	11	12	26.8	11
Knights Landing, Calif.	18	14	16	18.2	15
Mokelumne:					
Bensons Ferry, Calif.	12	7	7	12.9	7
Columbia:					
Vancouver, Wash.	15	5	10	16.8	9 and 10
Willamette:					
Eugene, Oreg.	12	4	5	14.2	5
Albany, Oreg.	20	5	7	23.5	6
Salem, Oreg.	20	5	7	20.7	6
Oregon City, Oreg.	12	(1)	11	14.7	7
Portland, Oreg.	15	3	11	19.5	8
Santiam:					
Jefferson, Oreg.	10	3	5	12.5	4
Clackamas:					
Three Links, Oreg.	8	3	3	8.3	3

[1] Continued from last month.
[2] No record for February; gage washed out.
[3] Estimated.
[4] Continued at end of month.

MEAN LAKE LEVELS DURING FEBRUARY, 1925

By UNITED STATES LAKE SURVEY

[Detroit, Mich., Mar. 6, 1925]

The following data are reported in the "Notice to Mariners" of the above date:

Data	Lakes [1]			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during February, 1925:	*Feet*	*Feet*	*Feet*	*Feet*
Above mean sea level at New York	600.96	578.24	570.49	244.41
Above or below—				
Mean stage of January, 1925	−0.16	±0.00	−0.13	+0.19
Mean stage of February, 1924	−.33	−.52	−.82	−.44
Average stage for February last 10 years	−.85	−1.50	−.96	−.78
Highest recorded February stage	−2.52	−4.48	−3.26	−3.26
Lowest recorded February stage	+.20	−.52	−.14	+.58
Average relation of the February level to:				
January level	----------	[2]	−.1	[2]
March level	----------	−.1	−.2	−.2

[1] Lake St. Clair's level: In February, 1925, 572.71 feet.
[2] Practically no difference.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS FEBRUARY, 1925

By J. B. KINCER

General summary.—The persistently mild weather that prevailed during nearly the whole of February permitted much outdoor work, especially in central and southern States. In the South, however, conditions were rather diversified as to moisture, as the soil was too wet for proper working during much of the month in parts of the Southeast, while it was too dry in the west Gulf area. Corn planting advanced in Florida, and there was some seeding done in the extreme lower Mississippi Valley, but in southern Texas seeding was being delayed because of insufficient moisture. There was some cotton planted in southern Texas, and much ground was prepared in other portions of the belt.

In the interior valley States a limited amount of plowing for spring crops was reported, and some spring grain was seeded as far north as Virginia and Kansas, but as a rule plowing had not become general in these sections at the close of the month. Vegetation made unusually rapid advance in the South, and winter grains began to show some green as far north as the middle Atlantic area and the southern portions of the Winter-Wheat Belt.

Small grains.—There was not much snow protection during the month in the Winter-Wheat Belt, but at the same time temperatures were mild and rather uniform and there was no widespread complaint of heaving; moisture was sufficient, except in some western and southwestern portions of the belt where it was too dry, particularly in north-central Kansas, central and western Oklahoma, and in Texas. In the more western and northwestern portions of the country, and also in the South, conditions were generally favorable for fall-sown grains, though there was considerable complaint of winter killing in parts of the far Northwest. At the close of the month the seeding of spring oats had commenced to south-central Kansas, the extreme lower Ohio Valley, and southeastern Virginia, at about the average date.

Ranges, pastures, and livestock.—In the southwestern grazing districts there was insufficient precipitation to materially improve the range, which continued in poor to only fair condition quite generally, including the extreme southern Great Plains. In the northern portions of the Great Plains, the Rocky Mountains, and the Pacific coast area conditions were more satisfactory, with pasturage much improved in California by reason of the more or less generous rainfall. The mild weather favorably affected livestock in the great western grazing districts, except for the cold wave about the close of the month which caused considerable suffering. In the central and eastern portions of the country grass lands were favorably affected by the weather of the month.

Fruit.—Influenced by the prevailing warmth, early fruit trees were blooming in the Gulf coast districts at the close of the month, and in the interior buds were beginning to swell northward to the lower Ohio Valley and in the east in sheltered places to Pennsylvania. This was a premature and unfavorable development and was causing considerable apprehension as to possible later frost damage. There was some local frost injury in the South, but in general this was not material. Citrus developed well in California, while the trees put on much new growth in Florida, except satsumas in the northwestern portion.

Miscellaneous crops.—Truck and miscellaneous crops made favorable advance in the Southern States, except where it was too dry in the west Gulf area and where frost injury occurred soon after the middle of the month in some more southeastern districts. The seeding of early potatoes advanced to eastern Oklahoma and southeastern Virginia and truck crops developed normally in south Atlantic sections. The latter part of the month was fairly favorable for maple sugar making in the upper Ohio Valley States.

CLIMATOLOGICAL TABLES [1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, February, 1925

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	53.5	+5.2	Spring Hill	82	14	2 stations	19	[2] 11	3.51	−1.79	Citronelle	5.59	Eufaula	1.85
Alaska (January)	3.0	−6.8	Dutch Harbor	53	4	Eagle	−69	[2] 22	3.08	−0.67	Speel River	11.50	Candle	0.00
Arizona	49.6	+3.0	Mohawk	92	28	Greer	6	8	0.24	−0.96	Ryan Ranger Station.	1.17	25 stations	0.00
Arkansas	49.3	+7.1	Texarkana	83	21	2 stations	12	[2] 2	3.37	+0.09	Brinkley	6.65	Rogers	1.04
California	50.8	+2.6	Elsinore	92	24	Tamarack	−8	24	5.95	+1.75	Upper Mattole	24.25	3 stations	0.00
Colorado	30.6	+4.4	Holly	74	5	Gunnison	−29	[2] 11	0.62	−0.54	Savage Basin	4.48	8 stations	0.00
Florida	63.0	+2.4	2 stations	88	[2] 10	Quincy	23	13	2.06	−1.12	Madison	6.59	Fellsmere	0.65
Georgia	53.6	+5.7	Saint George	85	[2] 7	Clayton	12	12	2.10	−2.87	Brunswick	5.44	Lisbon	1.02
Hawaii	70.2	+1.8	2 stations	89	[2] 8	Volcano Observatory.	48	[2] 11	3.04	−4.09	Eke	13.50	2 stations	0.00
Idaho	34.2	+5.9	Nezperce	64	21	Hill City	−23	10	2.27	+0.65	Wallace	6.82	Lemhi	0.10
Illinois	36.1	+8.4	Harrisburg	75	8	2 stations	−8	17	1.91	−0.17	Elgin	5.74	Danville	0.50
Indiana	37.8	+8.6	2 stations	74	[2] 7	Goshen	−1	28	1.73	−0.92	Mount Vernon	4.20	Crawfordsville	0.49
Iowa	28.4	+5.8	Perry	66	6	3 stations	−16	2	0.82	−0.38	Burlington	3.69	2 stations	T.
Kansas	39.9	+7.6	2 stations	78	[2] 5	2 stations	1	2	0.40	−0.72	Walnut	2.12	2 stations	0.00
Kentucky	44.0	+8.0	3 stations	76	[2] 7	Junction City	8	[2] 12	3.93	+0.40	2 stations	6.64	Oliver	1.93
Louisiana	58.4	+5.4	Baton Rouge	87	22	Kelly (near)	20	12	2.38	−2.19	Hammond	7.39	Franklin	0.46
Maryland-Delaware	41.2	+8.6	Western Port, Md.	75	8	Oakland, Md.	−2	28	1.62	−1.45	Wilmington, Del.	2.66	La Plata, Md.	0.66
Michigan	25.1	+6.8	3 stations	64	[2] 2	Humboldt	−27	28	1.57	−0.12	Whitefish Point	3.53	Muskegon	0.44
Minnesota	16.6	+5.9	2 stations	58	[2] 6	Red Lake Falls	−42	2	0.58	−0.18	Grand Marais	2.05	Alexandria	0.01
Mississippi	54.6	+5.9	Anguilla	85	22	Agricultural College.	19	12	3.81	−1.16	Water Valley	9.52	Bay St. Louis	1.22
Missouri	38.7	+6.9	Warsaw	78	6	Tarkio	1	2	1.85	−0.30	Parma	3.63	Grant City	0.45
Montana	30.4	+8.8	2 stations	65	[2] 11	Garland	−26	16	0.73	+0.01	Trout Creek	5.08	3 stations	T.
Nebraska	33.5	+8.4	Scottsbluff	69	3	4 stations	−11	[2] 2	0.58	−0.14	Springfield	1.95	6 stations	T.
Nevada	40.9	+5.8	Pahrump	81	23	2 stations	5	10	0.80	−0.09	Carson City	3.68	2 stations	0.00
New England	30.1	+8.2	2 stations	65	8	Houlton, Me.	−20	4	2.66	−0.60	Waterbury, Conn.	5.00	Nantucket, Mass.	1.02
New Jersey	37.3	+7.5	Vineland	72	22	Culvers Lake	−1	3	2.23	−1.38	Dover	4.64	Cape May City	1.18
New Mexico	40.7	+3.2	2 stations	84	[2] 4	Elizabethtown	−16	11	0.21	−0.46	Red River Canyon.	1.22	19 stations	0.00
New York	30.5	+8.9	2 stations	69	[2] 22	Philadelphia	−17	3	2.47	−0.29	North Lake	5.38	2 stations	1.02
North Carolina	49.0	+7.0	Weldon	82	23	Parker	5	12	2.15	−1.89	Manteo	5.40	Caroleen	0.40
North Dakota	16.5	+8.6	Berthold Agency	62	5	Grafton	−39	2	0.31	−0.18	Cando	1.80	4 stations	0.00
Ohio	36.3	+7.8	Portsmouth	76	8	Medina	−5	2	2.25	−0.17	Peebles	3.98	New Bremen	0.71
Oklahoma	47.8	+8.3	Pauls Valley	87	21	Goodwell	7	27	0.85	−0.65	Watts	4.25	Camargo	T.
Oregon	41.8	+4.9	2 stations	73	28	Crater Lake	2	1	4.37	+0.72	Willow Creek	17.22	Andrews	0.22
Pennsylvania	35.6	+8.1	2 stations	71	9	Saegerstown	−11	3	2.16	−0.71	Hamburg	4.61	Jersey Shore	0.55
Porto Rico	72.5	−0.9	Arecibo	93	26	Jayuya	49	4	3.84	+0.96	Adjuntas	8.57	Vieques	0.37
South Carolina	52.4	+5.3	Yemassee	80	23	Walhalla	19	13	1.69	−2.63	Georgetown	3.05	Blackville	0.70
South Dakota	26.0	+8.0	Dowling	71	4	3 stations	−18	2	0.31	−0.31	Hardy Ranger Station.	3.53	2 stations	0.00
Tennessee	47.4	+7.0	Carthage	77	8	Crossville	10	28	4.43	+0.30	Johnsonville	9.18	Copperhill	1.81
Texas	56.7	+6.2	Harlingen	96	22	2 stations	11	[2] 17	0.46	−1.40	Kaufman	3.53	47 stations	0.00
Utah	34.0	+4.8	Leeds (near)	71	18	2 stations	−25	10	1.02	−0.26	Silver Lake	4.37	Hanksville	0.13
Virginia	44.4	+7.9	Hopewell	77	8	Burkes Garden	6	28	1.67	−1.49	Burkes Garden	3.73	Dahlgren	0.59
Washington	40.7	+5.9	Puyallup	69	1	Snyder's Ranch	4	17	4.35	+0.63	Quinault	21.35	Prosser	0.28
West Virginia	39.8	+7.8	Burlington	80	9	Cheat Bridge	−5	28	2.49	−0.66	Spencer	4.32	Upper Tract	0.35
Wisconsin	21.4	+6.9	Watertown	61	9	Solon Springs	−30	27	1.17	+0.06	Beloit	3.40	2 stations	0.34
Wyoming	29.8	+7.8	Clearmont	74	3	Moran	−26	11	0.62	−0.10	Snake River	4.60	Diversion Dam	0.00

[1] For description of tables and charts, see REVIEW, January, 1925, p. 42.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, February, 1925*

Districts and stations	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
New England							32.9	+7.5										79	2.20	−1.1							5.9					
Eastport	76	67	85	29.92	30.01	+0.03	29.4	+7.9	50	12	35	7	4	23	24	28	24	83	1.95	−1.7	14	8,406	s.	46	s.	26	4	10	14	7.1	5.1	0.0
Greenville, Me	1,070	6	----	28.80	30.01	----	23.4	----	52	9	33	−5	3	14	39	----	----	----	3.56	----	13	----	se.	----	----	----	12	3	13	----	14.0	----
Portland, Me	103	82	117	29.92	30.05	+.03	30.6	+6.8	47	20	36	10	5	25	22	28	24	78	3.27	−0.4	11	5,890	n.	36	sw.	26	14	4	10	5.2	7.0	0.0
Concord	288	70	79	29.72	30.04	.00	30.0	+7.2	57	9	40	−4	5	21	42	----	----	----	2.46	−0.8	6	3,315	n.	35	w.	27	15	3	10	4.5	6.9	1.5
Burlington	404	11	48	29.56	30.02	−.01	26.9	+7.5	56	11	36	−1	3	18	39	----	----	----	2.25	+0.9	8	8,720	s.	52	s.	19	4	8	16	7.5	11.4	T.
Northfield	876	12	60	29.04	30.03	−.01	25.1	+8.7	55	9	37	−6	5	14	41	22	20	85	1.86	−0.4	9	5,670	s.	46	sw.	21	7	7	14	6.6	15.2	1.0
Boston	125	115	188	29.90	30.04	.00	38.0	+9.2	59	9	45	14	28	31	27	33	28	71	1.55	−1.9	6	6,919	w.	46	w.	26	12	4	12	5.6	T.	0.0
Nantucket	12	14	90	30.02	30.03	−.01	37.2	+6.5	59	9	43	16	28	31	24	35	33	88	1.02	−2.1	8	12,305	sw.	54	sw	26	6	8	14	6.4	T.	0.0
Block Island	26	11	46	30.00	30.03	−.03	36.8	+6.4	56	22	42	15	28	31	25	34	30	81	1.40	−2.9	7	12,154	w	64	w.	26	12	3	13	5.7	T.	0.0
Providence	160	215	251	29.87	30.05	.00	36.0	+7.0	59	22	43	12	28	28	25	32	27	75	2.08	−2.3	9	7,859	w.	68	nw.	26	13	2	13	5.2	0.2	0.0
Hartford	159	122	140	29.87	30.05	−.01	35.6	+8.4	61	22	43	11	28	28	26	----	----	----	3.30	−0.2	8	----	sw.	----	----	----	14	2	12	5.1	0.1	0.0
New Haven	106	74	153	29.93	30.05	−.02	35.8	+6.8	58	22	42	12	28	29	21	32	27	74	3.02	−0.7	8	5,388	ne.	44	w.	26	12	3	13	5.7	T.	0.0
Middle Atlantic States							40.5	+7.2										76	1.49	−1.7							5.6					
Albany	97	102	115	29.95	30.06	−.01	31.3	+7.2	57	9	40	0	4	23	32	28	25	80	2.06	−0.5	7	5,184	s.	38	s.	19	11	5	12	5.6	6.3	T.
Binghamton	871	10	84	29.06	30.01	−.07	32.4	+8.4	60	9	42	−2	3	23	36	----	----	----	1.65	−0.2	8	4,310	w.	34	w.	26	8	4	16	6.4	4.6	T.
New York	314	414	454	29.71	30.06	−.02	38.5	+7.2	63	22	46	12	28	31	22	34	28	71	1.92	−1.8	8	11,488	nw.	72	w.	26	9	7	12	6.1	0.6	0.0
Harrisburg	374	94	104	29.66	30.07	−.02	37.0	+6.8	62	22	44	13	28	30	28	33	29	74	1.60	−1.1	7	4,149	nw.	32	w.	26	6	8	14	6.2	T.	0.0
Philadelphia	114	123	190	29.94	30.07	−.03	42.2	+8.3	65	10	50	15	28	34	24	37	31	69	1.66	−1.7	7	5,735	nw.	33	nw.	26	9	10	9	5.7	0.3	0.0
Reading	325	81	98	29.70	30.06	----	37.4	----	62	22	45	13	3	29	24	34	31	82	2.33	−1.2	7	4,297	nw.	36	nw.	26	8	11	9	5.3	T.	0.0
Scranton	805	111	119	29.17	30.05	−.03	35.9	+8.6	64	9	45	6	3	27	28	32	29	83	1.79	−0.9	9	4,634	sw.	39	sw.	27	8	8	12	6.0	2.2	0.0
Atlantic City	52	37	172	30.00	30.06	−.05	39.8	+6.2	55	10	46	17	28	34	20	36	33	81	1.24	−2.0	9	12,192	s.	56	w.	26	11	7	10	5.0	T.	0.0
Cape May	17	13	49	30.07	30.10	−.01	40.2	+6.1	58	1	46	19	28	34	22	36	34	84	1.18	−2.1	10	5,685	s.	44	nw.	26	10	6	12	5.6	T.	0.0
Sandy Hook	22	10	55	30.03	30.05	----	36.8	----	60	22	43	14	28	30	23	33	29	77	1.66	----	8	9,563	w.	60	w.	26	10	7	11	5.5	0.2	0.0
Trenton	190	159	183	29.85	30.06	----	40.2	----	67	10	49	13	28	32	27	35	30	72	2.01	−1.2	7	6,744	s.	54	nw.	26	9	5	14	6.0	0.2	0.0
Baltimore	123	100	113	29.92	30.05	−.06	41.8	+6.4	67	23	49	18	28	34	24	37	32	73	0.98	−2.5	8	3,368	se.	26	w.	26	12	6	10	5.5	T.	0.0
Washington	112	62	85	29.93	30.06	−.05	43.0	+7.7	69	22	53	18	28	33	34	37	31	68	0.98	−2.4	8	4,327	s.	44	nw.	26	12	7	9	5.2	T.	0.0
Cape Henry	18	8	54	30.03	30.05	----	46.7	----	73	23	54	28	13	39	32	42	39	82	1.76	−2.0	8	8,592	sw.	48	nw.	12	8	10	10	5.6	0.0	0.0
Lynchburg	681	153	188	29.29	30.05	−.06	46.6	+6.3	75	8	59	22	28	35	42	40	35	71	1.04	−2.4	9	4,675	w.	35	nw.	12	11	6	11	5.3	0.0	0.0
Norfolk	91	170	205	29.98	30.08	−.03	49.2	+6.5	74	8	58	28	28	40	29	42	38	73	1.31	−2.4	9	9,016	s.	61	w.	26	11	7	10	5.3	0.0	0.0
Richmond	144	11	52	29.91	30.07	−.04	47.4	+7.8	75	23	58	21	28	37	33	41	36	74	0.90	−2.2	10	5,950	s.	40	w.	23	12	10	6	4.4	0.0	0.0
Wytheville	2,304	49	55	27.64	30.06	−.06	42.1	+7.0	68	8	52	12	12	32	36	37	33	76	0.95	−3.1	8	4,469	w.	37	nw.	12	10	4	14	5.5	0.4	0.0
South Atlantic States							53.1	+5.2										77	1.95	−1.9							5.1					
Asheville	2,255	70	84	27.68	30.07	−.06	44.9	+6.4	71	7	56	15	12	34	37	39	34	73	1.85	−1.4	10	6,427	se.	38	n.	12	10	11	7	4.8	0.1	0.0
Charlotte	779	55	62	29.22	30.06	−.06	50.6	+6.7	73	8	60	27	13	41	30	44	39	70	1.91	−2.5	10	3,566	s.	21	w.	26	11	3	14	5.5	0.0	0.0
Hatteras	11	11	50	30.05	30.06	−.05	52.2	+4.8	70	23	59	34	13	45	27	48	45	84	3.79	−0.7	11	9,388	n.	46	n.	18	8	8	12	5.5	0.0	0.0
Manteo	12	5	42	----	----	----	49.0	----	70	9	----	30	6	----	34	----	----	----	5.40	----	9	----	se.	----	----	----	12	5	11	----	0.0	0.0
Raleigh	376	103	110	29.66	30.07	−.04	50.6	+7.4	75	23	61	24	4	40	29	43	38	71	1.70	−2.6	10	5,372	sw.	40	sw.	15	10	6	12	5.1	0.0	0.0
Wilmington	78	81	91	30.00	30.09	−.03	54.2	+6.3	74	16	64	30	4	44	30	48	45	81	2.52	−0.9	9	4,668	s.	28	sw.	23	11	10	7	4.8	0.0	0.0
Charleston	48	11	92	30.03	30.08	−.04	55.6	+3.2	72	15	64	32	12	48	24	50	47	81	1.84	−1.6	10	6,177	sw.	32	ne.	18	13	6	9	4.8	0.0	0.0
Columbia, S. C	351	41	57	29.70	30.09	−.03	53.8	+5.6	75	8	64	29	13	44	30	48	44	78	1.08	−3.5	9	4,361	s.	31	sw.	15	12	6	10	4.9	0.0	0.0
Due West	711	10	55	29.31	30.10	----	50.3	----	72	8	60	24	13	40	32	----	----	----	1.03	----	7	5,257	sw.	33	w.	26	11	6	11	5.4	0.0	0.0
Greenville, S. C	1,039	113	122	28.94	30.05	----	50.0	+6.7	70	8	58	24	12	42	30	44	38	70	1.20	----	8	4,317	sw.	34	w.	26	10	7	11	5.4	0.0	0.0
Augusta	182	62	77	29.88	30.07	−.05	54.0	+4.1	75	8	65	28	12	43	36	48	45	81	1.14	−3.2	8	3,418	nw.	30	w.	11	11	7	10	5.2	0.0	0.0
Savannah	65	150	194	30.01	30.08	−.04	58.0	+4.0	78	23	67	28	12	49	27	51	48	80	2.80	−0.5	10	7,666	s.	42	nw.	26	13	6	9	4.5	0.0	0.0
Jacksonville	43	209	245	30.04	30.09	−.03	60.2	+2.2	77	21	68	30	12	52	29	54	50	78	0.90	−2.5	7	8,072	sw.	38	nw.	12	11	7	10	5.3	0.0	0.0
Florida Peninsula							68.3	+1.2										79	1.60	−0.8							4.5					
Key West	22	10	64	30.03	30.05	−.02	71.8	+1.3	82	28	77	58	13	67	16	66	63	79	1.89	+0.2	6	6,563	se.	40	nw.	12	11	12	5	4.2	0.0	0.0
Miami	25	71	79	30.05	30.08	----	68.9	+0.1	80	24	75	40	13	62	28	63	60	79	1.27	−0.9	9	5,065	e.	25	nw.	12	9	13	6	4.7	0.0	0.0
Tampa	35	79	87	30.04	30.08	−.02	64.2	+2.3	82	22	73	38	13	55	27	57	54	79	1.63	−1.6	6	4,178	e.	28	w.	17	11	12	5	4.7	0.0	0.0
East Gulf States							55.2	+3.9										76	2.70	−2.1							5.4					
Atlanta	1,174	190	216	28.82	30.08	−.04	51.1	+5.8	71	8	59	20	12	43	35	45	40	72	1.70	−3.0	9	8,006	nw.	56	nw.	11	10	7	11	5.5	0.0	0.0
Macon	370	78	87	29.68	30.08	−.04	53.4	+4.1	76	8	64	28	12	43	35	47	42	75	1.94	−2.6	9	3,944	nw.	33	nw.	11	11	6	11	5.3	0.0	0.0
Thomasville	273	49	58	29.78	30.08	−.04	58.0	+3.0	80	22	68	28	12	48	33	51	47	76	1.86	−2.6	7	3,046	sw.	22	sw.	15	9	8	11	5.4	0.0	0.0
Apalachicola	36	42	49	30.04	30.08	----	58.2	----	72	23	64	33	12	52	24	54	52	85	2.89	----	8	4,777	e.	30	se.	28	13	9	6	4.4	0.0	0.0
Pensacola	56	149	185	30.02	30.08	−.03	57.9	+2.7	71	10	64	32	12	52	24	54	52	86	2.73	−1.8	4	8,512	s.	38	nw.	11	7	9	12	6.1	0.0	0.0
Anniston	741	9	57	29.30	30.10	−.02	50.8	+5.0	76	22	62	23	12	40	38	----	----	----	2.86	−1.8	9	4,273	s.	30	nw.	11	10	9	9	5.1	0.0	0.0
Birmingham	700	11	48	29.32	30.10	−.02	52.0	+4.0	75	8	62	23	12	42	30	45	39	68	3.32	−1.4	11	5,653	s.	28	se.	22	10	7	11	5.3	T.	0.0
Mobile	57	125	161	30.01	30.07	−.04	57.4	+2.7	81	23	66	33	12	49	25	52	49	82	2.53	−2.8	7	6,869	s.	38	nw.	11	5	14	9	5.8	0.0	0.0
Montgomery	223	100	112	29.83	30.08	−.04	55.2	+3.6	77	8	65	26	12	46	33	48	44	72	3.97	−1.6	7	4,844	se.	30	sw.	9	10	10	8	5.0	0.0	0.0
Meridian	375	85	93	29.67	30.08	−.03	54.0	+4.4	77	22	64	28	12	44	34	48	44	75	4.35	−0.6	11	4,254	s.	29	nw.	11	9	9	10	5.4	0.0	0.0
Vicksburg	247	65	73	29.80	30.08	−.02	55.8	+4.0	80	22	66	31	4	46	33	48	43	72	2.77	−1.8	7	5,762	se.	35	nw.	22	8	11	12	6.0	0.0	0.0
New Orleans	53	76	84	30.01	30.07	−.02	61.2	+3.9	80	23	70	39	5	52	29	55	51	78	1.64	−2.8	6	4,678	s.	24	n.	11	7	13	8	5.4	0.0	0.0
West Gulf States							57.2	+5.9										72	1.00	−1.7							4.6					
Shreveport	249	77	93	29.77	30.04	−.05	56.2	+5.3	82	21	67	33	3	46	32	48	42	66	0.83	−2.8	3	5,417	se.	30	nw.	10	14	8	6	4.0	0.0	0.0
Bentonville	1,303	11	44	----	----	----	45.0	+6.5	74	5	57	17	27	33	34	----	----	----	2.07	----	6	4,389	s.	26	s.	22	18	6	4	----	1.0	0.0
Fort Smith	457	79	94	29.51	30.00	−.10	48.3	+5.5	78	21	59	24	2	38	34	43	38	72	1.66	−1.1	4	6,528	e.	48	sw.	8	9	10	9	5.4	0.0	0.0
Little Rock	357	136	144	29.64	30.02	−.09	50.0	+5.1	76	21	60	23	27	40	32	44	38	67	3.78	−0.4	10	6,457	s.	44	w.	10	7	10	11	6.0	2.2	T.
Brownsville	57	4	26	29.94	30.00	----	66.8	+4.2	83	25	76	39	12	58	29	60	57	80	0.10	----	1	6,219	s.	34	sw.	22	12	11	5	4.4	0.0	0.0
Corpus Christi	20	11	73	30.01	30.03	−.02	64.9	+6.5	85	25	72	42	12	57	23	59	56	80	0.36	−1.7	1	8,739	se.	37	s.	13	11	7	10	5.2	0.0	0.0
Dallas	512	109	117	29.47	30.02	----	55.5	----	84	21	68	27	2	43	36	----	----	----	1.20	----	3	6,858	s.	33	sw.	22	14	10	4	4.0	0.0	0.0
Fort Worth	670	106	116	29.27	29.99	−.08	55.9	+7.6	83	6	68	27	2	44	34	48	41	62	0.74	−0.5	2	7,984	s.	45	w.	22	15	10	3	3.9	0.0	0.0
Galveston	54	106	114	30.00	30.06	−.01	60.6	+4.3	78	25	66	42	3	55	21	56	54	84	0.20	−2.9	4	7,397	s.	31	nw.	10	11	8	9	4.7	0.0	0.0
Groesbeck	461	11	56	29.54	30.03	----	56.4	----	82	21	69	28	12	44	36	----	----	----	0.47	----	3	8,515	s.	36	sw.	13	12	11	5	4.4	0.0	0.0
Houston	138	111	121	29.90	30.05	----	61.9	+6.0	79	21	72	37	3	52	33	----	----	----	0.63	----	6	5,109	s.	24	n.	10	13	10	5	4.2	0.0	0.0
Palestine	510	64	72	29.50	30.03	−.05	56.5	+5.3	82	21	67	30	3	46	31	49	42	63	0.96	−2.4	5	6,176	s.	29	s.	22	11	10	7	4.8	0.0	0.0
Port Arthur	34	58	66	30.00	30.04	----	59.7	----	79	25	68	35	3	52	25	55	52	83	1.49	----	5	6,242	s.	28	nw.	25	9	10	9	5.3	0.0	0.0
San Antonio	693	119	132	29.29	30.02	−.03	61.5	+6.1	83	6	74	36	12	50	33	52	43	59	0.09	−1.7	2	5,468	s.	36	w.	8	14	7	7	4.3	0.0	0.0
Taylor	583	55	63	29.45	30.06	.00	59.2	+7.9	80	7	72	31	12	46	35	----	----	----	0.39	−2.2	2	7,262	s.	32	nw.	8	13	9	6	4.4	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, February, 1925*—Continued

Districts and stations	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dewpoint	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles							0–10	In.	In.
Ohio Valley and Tennessee							42.6	+6.5										73	2.67	−0.9									6.1		
Chattanooga	762	189	213	29.25	30.08	−.05	49.0	+4.9	72	8	59	18	12	39	40	42	37	68	2.58	−2.4	11	5,805	w.	36	sw.	23	7	12	9	5.4	T.	0.0
Knoxville	996	102	111	28.99	30.06	−.06	47.3	+5.4	73	8	58	20	12	37	39	42	37	75	2.56	−2.3	9	4,326	ne.	40	sw.	23	6	12	10	5.7	T.	0.0
Memphis	399	76	97	29.61	30.04	−.07	49.7	+5.4	72	8	58	26	27	41	27	44	38	70	4.52	+0.2	10	5,995	s.	53	sw.	8	7	11	10	5.9	T.	0.0
Nashville	546	168	191	29.48	30.08	−.04	47.4	+5.8	73	8	57	20	12	38	33	42	37	72	4.88	+0.6	12	7,099	s.	40	nw.	11	7	11	10	5.9	0.2	0.0
Lexington	989	193	230	28.97	30.06	−.05	43.0	+7.6	71	8	52	13	27	34	34				3.02	−0.2	11	10,470	sw.	48	nw.	26	4	9	12	5.8	1.5	0.0
Louisville	525	188	234	29.47	30.06	−.05	43.2	+6.0	71	8	52	14	27	34	31	38	32	67	3.10	−0.6	9	8,084	s.	40	nw.	11	7	11	10	5.8	0.3	0.0
Evansville	431	139	175	29.58	30.06	−.05	43.2	+6.9	72	8	52	16	27	34	31	38	33	71	2.99	−0.1	13	8,197	sw.	40	n.	11	7	11	10	5.6	0.8	0.0
Indianapolis	822	194	230	29.13	30.04	−.06	37.8	+6.7	68	8	46	7	27	30	26	34	30	77	1.64	−1.4	10	8,628	s.	39	nw.	26	8	7	13	6.2	2.5	0.0
Royal Center	736	11	55	29.19	30.02	------	33.8	------	67	8	42	4	27	25	26				1.59	------	8	7,823	s.	38	n.	10	4	8	16	7.1	0.2	0.0
Terre Haute	575	96	129	29.40	30.03	------	38.6	------	66	7	47	8	27	30	27	34	29	74	1.23	------	10	7,574	s.	34	nw.	11	8	10	10	5.8	1.5	0.0
Cincinnati	628	11	51	29.36	30.05	−.05	40.3	+7.5	71	8	49	10	27	31	33				2.33	−0.9	9	5,797	sw.	32	sw.	9	8	10	10	5.7	0.3	0.0
Columbus	824	179	222	29.14	30.04	−.05	37.6	+6.9	69	8	46	7	27	29	29	34	30	77	1.77	−1.3	9	7,388	s.	49	w.	26	9	10	9	5.6	0.4	0.0
Dayton	899	137	173	29.05	30.03	------	38.4	+7.0	69	8	46	9	27	30	30	34	30	74	1.98	−1.1	9	7,407	sw.	40	nw.	26	8	8	12	5.7	0.2	0.0
Elkins	1,947	59	67	27.96	30.07	−.03	39.8	+8.2	69	8	51	7	28	28	40	34	30	78	1.97	−1.2	10	3,844	w.	33	w.	26	5	10	13	7.0	1.2	T.
Parkersburg	638	77	84	29.39	30.06	−.04	40.4	+6.2	71	8	50	13	28	30	36	35	31	76	2.09	−1.2	11	3,716	se.	34	nw.	26	5	7	16	7.2	2.9	0.0
Pittsburgh	842	353	410	29.12	30.04	−.05	39.2	+6.9	68	8	48	9	28	30	29	35	30	73	1.91	−0.8	12	6,765	w.	44	w.	26	3	12	13	6.7	2.7	T.
							31.8	+6.7										78	2.60	+0.2									7.1		
Lower Lake Region																															
Buffalo	767	247	280	29.16	30.01	−.05	30.8	+6.5	62	8	38	4	28	24	34	28	24	81	2.90	0.0	13	12,256	sw.	74	w.	26	3	11	14	7.0	9.2	T.
Canton	448	10	61	29.47	29.97	------	25.1	+7.1	63	9	34	−11	3	16	39				3.16	+0.6	14	7,889	sw.	55	sw.	21	8	3	17	6.4	10.3	0.7
Oswego	335	76	91	------	30.01	−.05	30.0	+6.1	56	9	37	−3	3	23	32			85	3.67	+1.1	12	------	s.	44	w.	26	4	4	20	----	29.1	12.0
Rochester	523	86	102	29.43	30.01	−.05	32.1	+7.5	63	8	40	7	28	25	32	28	23	73	2.48	−0.4	12	6,068	w.	46	w.	27	2	7	19	7.8	6.4	0.0
Syracuse	597	97	113	29.37	30.03	−.04	32.2	+7.6	60	8	40	−2	3	25	37				2.46	+0.7	11	8,420	s.	52	w.	27	2	7	19	7.8	12.3	T.
Erie	714	130	166	29.22	30.01	−.06	32.8	+5.9	65	8	40	5	28	26	28	29	25	78	2.20	−0.6	11	10,073	s.	52	w.	26	3	7	18	7.2	6.9	T.
Cleveland	762	190	201	29.18	30.02	−.05	33.8	+6.4	65	8	42	6	28	26	28	30	26	76	2.42	−0.2	9	9,775	s.	50	w.	26	2	9	17	7.6	2.1	0.4
Sandusky	629	62	70	29.32	30.02	−.05	34.2	+6.8	65	8	42	7	27	26	26				2.34	0.0	8	6,019	sw.	35	w.	26	5	9	14	6.9	0.9	0.0
Toledo	628	208	243	29.33	30.03	−.04	33.4	+6.1	63	8	41	5	27	26	25	30	26	77	2.31	+0.4	6	10,195	sw.	52	w.	26	7	10	11	6.1	2.3	0.0
Fort Wayne	856	113	124	29.08	30.03	------	34.4	+8.6	68	8	43	5	27	26	29	31	27	78	1.98	------	7	6,965	s.	34	sw.	25	7	8	13	6.6	0.5	T.
Detroit	730	218	258	29.20	30.02	−.04	30.8	+5.5	59	8	38	5	27	24	25	28	24	77	2.10	−0.1	10	7,448	nw.	52	sw.	9	3	8	17	7.3	2.7	T.
							23.3	+4.0										83	1.33	−0.4									7.2		
Upper Lake Region																															
Alpena	609	13	92	29.30	30.00	−.03	22.0	+4.0	45	9	29	−4	27	15	27	20	18	84	1.02	−0.8	12	8,438	nw.	46	nw.	26	4	9	15	7.1	7.4	T.
Escanaba	612	54	60	29.31	30.01	−.05	18.4	+3.0	47	7	26	−13	27	10	30	17	15	85	1.35	0.0	11	6,236	nw.	29	nw.	26	6	9	13	6.6	6.9	4.0
Grand Haven	632	54	89	29.29	30.00	−.05	27.7	+3.5	60	8	35	2	28	20	29	26	23	83	0.86	−1.0	11	8,503	w.	50	w.	26	4	6	18	7.7	3.5	1.1
Grand Rapids	707	70	87	29.22	30.02	−.04	28.8	+4.6	60	8	36	1	27	22	26	26	23	80	1.31	−0.6	9	4,584	nw.	29	nw.	25	3	5	20	8.0	6.1	1.0
Houghton	668	62	99	29.23	29.98	−.07	16.4	+2.7	51	6	24	−13	27	8	35				1.54	−0.2	15	6,703	w.	34	w.	9	4	7	17	7.3	12.8	13.9
Lansing	878	11	62	29.03	30.00	------	27.3	+4.4	56	8	36	−2	17	19	35	25	22	85	1.84	−0.2	9	4,922	s.	32	nw.	26	6	9	13	6.5	7.5	T.
Ludington	637	60	66	29.28	29.99	------	26.0	------	57	8	33	−1	27	19	28	25	22	83	1.32	------	17	8,061	w.	40	nw.	26	5	5	18	7.5	9.5	1.7
Marquette	734	77	111	29.18	30.01	−.04	18.7	+2.4	51	6	26	−16	27	12	33	17	14	83	0.77	−1.0	11	6,826	nw.	37	s.	4	4	5	19	7.7	5.7	7.3
Port Huron	638	70	120	29.28	30.00	−.05	28.0	+5.3	52	8	35	2	3	21	26	26	23	84	2.00	−0.2	13	8,242	s.	42	nw.	26	3	10	15	7.1	5.8	0.0
Saginaw	641	69	77	29.29	30.01	------	26.8	+4.9	53	8	35	0	27	19	32	24	22	85	1.38	−0.7	10	6,081	nw.	28	sw.	9	3	9	16	7.6	5.6	1.6
Sault Sainte Marie	614	11	52	29.27	30.00	−.03	15.8	+3.2	41	9	24	−14	2	8	36	14	12	84	1.17	−0.2	16	6,269	nw.	40	nw.	26	4	6	18	7.4	6.3	8.8
Chicago	823	140	310	29.10	30.02	−.06	32.2	+4.8	62	8	39	1	27	25	26	30	25	75	1.62	−0.5	8	8,061	s.	40	s.	20	6	7	15	6.6	4.6	0.0
Green Bay	617	109	141	29.30	29.99	−.07	22.0	+4.6	56	8	30	−11	27	14	29	20	17	84	1.79	+0.2	8	7,853	s.	44	nw.	26	4	9	15	6.9	7.9	0.2
Milwaukee	681	125	139	29.24	30.01	−.05	27.4	+4.6	55	8	35	−4	27	20	29	26	22	81	1.30	−0.6	12	6,654	sw.	28	ne.	23	6	4	18	7.3	4.2	T.
Duluth	1,133	5	47	28.73	30.01	−.07	15.2	+3.8	51	6	23	−21	27	7	31	13	11	88	0.71	−0.3	10	9,102	nw.	47	nw.	28	9	4	15	6.3	7.5	3.7
							16.4	+8.7										80	0.42	−0.1									6.6		
North Dakota																															
Moorhead	940	50	58	28.99	30.05	−.06	14.0	+5.9	51	4	23	−23	2	5	39	13	10	81	0.97	+0.2	11	5,520	n.	26	nw.	25	7	7	14	6.5	10.6	5.0
Bismarck	1,674	8	57	28.21	30.08	−.04	20.0	+9.7	50	3	30	−16	1	10	38	17	13	78	0.05	−0.4	2	5,712	n.	38	nw.	25	2	13	13	7.1	2.3	0.0
Devils Lake	1,478	11	44	28.39	30.05	−.06	12.2	+7.7	45	5	21	−27	1	3	52	10	8	86	0.49	0.0	7	6,903	nw.	34	nw.	25	8	7	13	6.2	8.0	3.5
Ellendale	1,457	10	56	28.42	30.04	------	18.7	------	51	4	28	−20	2	9	40				0.05	------	3	8,491	nw.	48	nw.	25	2	14	12	6.9	1.2	T.
Grand Forks	835	12	89	------	------	------	12.2	------	50	4	22	−32	2	3	47	10	----	----	0.35	------	6	----	nw.	33	nw.	25	13	10	5	----	3.3	4.5
Williston	1,878	41	48	27.96	30.02	−.09	19.6	+11.5	49	5	29	−20	1	10	50	18	13	77	0.18	−0.3	4	5,038	se.	28	w.	5	6	13	9	6.2	2.9	T.
							30.6	+6.1										79	1.41	−0.3									6.4		
Upper Mississippi Valley																															
Minneapolis	918	102	208	29.99	30.01	------	21.6	+5.7	51	6	29	−7	27	14	26	----	----	----	0.41	−0.3	7	7,682	nw.	42	nw.	25	4	8	16	7.2	4.2	1.2
St. Paul	837	236	261	29.08	30.02	−.07	21.1	+5.3	50	6	28	−8	27	14	27	----	----	----	0.62	−0.2	7	7,953	nw.	46	nw.	25	4	11	13	6.8	5.5	1.5
La Crosse	714	11	48	29.22	30.02	−.06	24.4	+5.2	51	6	33	−7	27	16	29	----	----	----	0.74	−0.3	5	3,773	se.	22	w.	26	5	6	17	7.2	7.3	T.
Madison	974	70	78	28.94	30.03	−.04	25.0	+5.9	55	8	33	−6	27	17	29	23	20	83	1.17	−0.3	7	5,997	nw.	26	nw.	13	5	5	18	7.5	3.6	0.0
Wausau	1,247	4	----	28.62	30.02	------	18.8	------	46	7	26	−15	27	11	30	----	----	----	0.88	------	8	----	nw.	----	----	----	6	6	16	7.1	8.2	3.0
Charles City	1,015	10	49	28.92	30.04	−.06	24.2	+7.1	51	6	33	−5	27	16	32	22	19	84	0.57	−0.4	4	4,733	nw.	26	nw.	25	5	9	14	6.4	3.2	0.0
Davenport	606	71	79	29.34	30.03	−.07	30.7	+5.8	58	8	39	2	27	22	33	28	26	83	1.94	+0.4	9	5,259	nw.	30	nw.	25	7	6	15	6.4	1.6	0.0
Des Moines	861	84	97	29.09	30.02	−.09	30.7	+7.0	60	4	40	4	27	21	34	27	23	76	0.50	−0.6	3	4,906	n.	31	sw.	3	8	7	13	6.3	0.4	0.0
Dubuque	700	81	96	29.23	30.01	−.08	27.7	+5.5	56	6	36	−2	27	19	33	25	21	79	1.08	−0.3	11	4,731	nw.	31	nw.	26	6	6	19	6.9	2.7	0.1
Keokuk	614	64	78	29.34	30.04	−.07	33.6	+5.3	62	8	43	5	27	24	31	30	26	74	1.71	+0.1	8	5,237	s.	29	w.	8	8	7	13	6.0	5.6	0.0
Cairo	358	87	93	29.64	30.04	−.08	44.4	+5.9	70	20	53	20	27	36	30	39	34	70	2.82	−0.5	12	7,112	s.	40	nw.	11	6	7	15	6.5	T.	0.0
Peoria	609	11	45	29.35	30.04	−.06	33.1	+7.2	63	7	42	4	27	24	26	30	28	86	1.99	−0.7	9	5,024	s.	27	nw.	25	10	7	11	5.6	1.1	0.0
Springfield, Ill	636	10	91	29.31	30.01	−.09	36.4	+6.9	65	8	44	8	27	28	24	33	30	82	1.65	−1.1	6	6,326	s.	30	sw.	8	11	5	12	5.6	4.0	1.4
Hannibal	534	74	109	29.45	30.04	−.07	35.4	+5.7	65	7	44	8	27	27	30	----	----	----	2.40	+0.8	6	5,657	nw.	33	nw.	25	11	3	14	5.7	6.0	0.6
St. Louis	568	265	303	29.40	30.02	−.09	40.8	+6.3	69	6	49	12	27	32	27	36	31	73	2.19	−0.6	6	9,493	s.	52	sw.	8	9	8	11	5.5	3.4	0.9
							33.1	+7.4										76	0.72	−0.3									5.6		
Missouri Valley																															
Columbia, Mo	784	11	84	29.17	30.03	−.08	37.5	+5.8	64	20	47	10	27	28	34	----	----	----	1.41	−0.7	6	5,828	s.	31	n.	10	11	5	12	5.6	3.3	0.5
Kansas City	963	161	181	28.96	30.02	−.09	38.0	+6.8	66	7	48	9	2	28	32	33	29	74	1.75	+0.2	7	7,337	s.	42	n.	10	12	7	9	4.9	1.2	0.0
St. Joseph	967	11	49	28.95	30.01	------	35.6	------	64	7	45	8	2	26	31	31	27	77	0.87	------	5	5,892	nw.	34	nw.	10	12	8	8	4.6	0.7	T.
Springfield, Mo	1,324	98	104	28.59	30.02	−.09	41.5	+6.3	71	5	52	12	27	31	33	36	31	73	1.06	−1.2	9	7,992	s.	34	nw.	10	13	6	9	4.8	1.0	T.
Iola	984	11	50	28.94	30.02	−.08	40.0	+8.0	70	7	52	11	2	28	38	----	----	----	0.63	−0.5	7	5,024	s.	26	n.	10	10	7	11	5.4	T.	0.0
Topeka	987	92	107	------	------	------	37.7	+6.7	67	7	48	7	2	27	34	----	----	----	0.55	−0.8	4	6,758	n.	40	n.	10	14	7	7	4.2	1.5	0.0
Drexel	1,299	10	54	28.58	30.00	------	29.3	------	58	20	38	−10	2	21	33	----	----	----	0.86	------	4	6,801	n.	28	s.	19	7	9	12	6.1	2.3	0.0
Lincoln	1,189	11	84	28.73	30.04	−.06	33.2	+7.1	60	20	42	−3	2	24	31	29	25	76	1.70	+1.0	3	6,332	n.	38	n.	22	6	11	11	6.3	1.5	0.0
Omaha	1,105	115	122	28.82	30.04	−.07	31.6	+6.1	61	20	40	−4	2	23	29	28	23	75	0.61	−0.2	4	6,300	nw.	33	nw.	25	8	14	6	5.1	1.0	0.0
Valentine	2,598	47	54	27.22	30.01	−.08	32.4	+11.0	65	5	44	1	1	21	54	27	22	72	0.23	−0.4	6	5,733	n.	33	nw.	24	5	16	7	5.8	3.2	T.
Sioux City	1,135	94	164	28.80	30.06	−.06	27.0	+6.0	52	24	34	−9	2	20	28	25	21	80	0.17	−0.4	8	8,102	nw.	46	nw.	25	8	9	11	5.9	1.2	T.
Huron	1,306	59	74	28.62	30.03	−.04	23.8	+9.5	50	4	32	−10	2	15	36	21	18	82	0.16	−0.3	4	6,181	s.	33	ne.	28	6	12	10	6.3	1.9	T.
Pierre	1,572	70	75	28.32	30.04	−.07	28.2	+9.6	60	23	38	−2	2	19	37	25	21	78	0.34	−0.1	4	5,412	nw.	35	nw.	25	8	7	13	6.2	3.2	T.
Yankton	1,233	49	57	28.66	30.03	−.09	26.7	+5.8	53	24	35	−10	2	18	39	----	----	----	0.08	−0.5	3	5,265	nw.	31	nw.	25	6	10	12	6.5	0.2	T.

TABLE 1.—*Climatological date for Weather Bureau stations, February, 1925*—Continued

Districts and stations	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dewpoint	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F.	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
Northern Slope							31.8	+10.1										66	0.46	−0.3										6.2		
Billings	3,140	5					33.6		64	3	46	−9	16	21	46				0.53		4		sw.				8	9	11		7.5	0.0
Havre	2,505	11	44	27.26	29.98	−.09	23.4	+9.8	57	3	34	−14	16	12	47	21	18	82	0.53	+0.1	7	4,741	e.	50	sw.	5	10	13	5	4.6	5.4	1.8
Helena	4,110	87	112	25.68	29.93	−.18	35.1	+12.1	59	3	44	9	16	27	35	29	21	56	0.48	−0.3	9	5,679	sw.	38	w.	5	1	7	20	7.9	3.5	0.0
Kalispell	2,973	48	56	26.81	29.90	−.18	35.8	+12.5	52	22	42	15	10	30	22	31	25	67	0.38	−1.1	6	3,578	sw.	24	sw.	24	1	12	15	7.4	0.6	0.0
Miles City	2,371	48	55	27.43	30.06	−.03	27.4	+10.6	52	22	36	−14	16	18	47	25	21	77	0.51	0.0	7	3,074	s.	28	w.	24	6	8	14	6.4	2.5	T.
Rapid City	3,259	50	58	26.52	30.04	−.04	32.4	+9.0	63	21	43	−2	16	22	53	27	20	64	0.15	−0.3	5	4,556	n.	31	n.	25	6	10	12	6.4	1.5	0.1
Cheyenne	6,088	84	101	23.90	29.96	−.06	34.6	+7.3	61	3	45	14	10	24	36	28	17	50	0.29	−0.3	4	11,827	w.	54	w.	24	3	13	12	6.6	2.6	T.
Lander	5,372	60	68	24.55	29.98	−.10	34.6	+12.1	60	3	46	14	11	23	32	28	19	55	T.	−0.6	0	4,105	sw.	52	sw.	23	9	17	2	4.6	T.	0.0
Sheridan	3,790	10	47	26.01	30.01	------	31.0	------	63	2	43	−1	16	19	40	25	18	64	0.82	------	7	2,959	nw.	36	sw.	5	5	17	6	5.7	10.0	2.2
Yellowstone Park	6,241	11	48	23.78	30.04	−.06	27.6	+8.0	42	3	34	7	11	21	33	24	20	71	1.29	−0.6	16	7,197	s.	41	s.	3	3	7	18	7.8	7.7	12.2
North Platte	2,821	11	51	27.04	30.04	−.03	35.7	+9.1	64	4	47	11	2	24	36	29	24	72	0.51	+0.1	3	4,617	n.	32	nw.	24	11	10	7	5.1	1.1	T.
Middle Slope							41.3	+7.5										58	0.23	−0.5										4.2		
Denver	5,292	106	113	24.64	29.95	−.06	41.0	+8.3	66	3	52	20	14	30	36	31	16	39	0.04	−0.4	2	5,610	s.	37	n.	22	12	13	3	4.3	0.6	T.
Pueblo	4,685	80	86	25.21	29.95	−.05	40.6	+7.7	73	3	55	15	11	26	46	32	21	49	0.23	−0.2	1	5,541	nw.	36	nw.	9	12	12	4	4.2	2.0	T.
Concordia	1,392	50	58	28.50	30.01	−.08	37.4	+7.6	63	20	48	6	2	27	36	31	26	70	0.11	−0.6	4	5,066	n.	26	nw.	23	9	10	9	5.2	0.4	0.0
Dodge City	2,509	11	51	27.38	30.03	−.03	41.3	+8.1	77	4	56	14	27	27	44	32	25	65	0.21	−0.5	2	6,655	nw.	32	nw.	10	18	8	2	3.0	T.	0.0
Wichita	1,358	139	158	28.53	29.99	−.09	41.2	+6.8	69	20	52	12	2	30	31	35	28	64	0.10	−1.0	3	8,749	s.	38	s.	20	14	9	5	4.1	T.	0.0
Broken Arrow	765	11	52	29.17	30.01	------	45.0	------	74	7	57	16	2	33	34	------	------	------	0.67	------	4	9,687	s.	46	s.	20	12	9	7	5.1	T.	0.0
Muskogee	652	4	------	------	------	------	48.6	------	76	21	60	22	2	37	35	------	------	------	2.05	------	6	------	s.	------	------	------	11	10	7	------	0.0	0.0
Oklahoma City	1,214	10	47	28.70	30.00	−.07	46.2	+6.6	76	7	59	19	2	34	37	38	30	62	0.69	−0.3	2	8,172	s.	44	nw.	21	13	12	3	3.6	0.0	0.0
Southern Slope							52.6	+6.6										40	0.03	−0.8										3.6		
Abilene	1,738	10	52	28.18	30.00	−.05	54.7	+7.5	83	5	69	25	27	40	43	41	25	38	0.07	−1.0	1	7,455	s.	40	w.	22	11	10	7	4.9	0.0	0.0
Amarillo	3,676	10	49	26.21	29.98	−.04	46.6	+8.5	81	4	61	18	27	32	44	35	24	49	0.06	−0.8	3	7,299	sw.	39	nw.	22	19	8	1	3.2	0.0	0.0
Del Rio	944	64	71	29.04	30.03	+.03	60.0	+4.0	86	6	73	32	28	47	40	------	------	------	0.00	−0.9	0	5,721	se.	42	nw.	22	17	7	4	3.3	0.0	0.0
Roswell	3,566	75	85	26.34	29.97	−.01	49.0	+6.5	80	4	66	22	27	32	50	36	17	33	T.	−0.5	0	6,042	nw.	52	nw.	22	21	6	1	2.2	0.0	0.0
Southern Plateau							48.4	+3.6										44	0.09	−0.6										3.1		
El Paso	3,762	110	133	26.20	29.98	+.03	53.4	+4.4	76	4	67	34	26	40	38	39	19	28	0.05	−0.4	2	6,916	w.	43	w.	7	18	7	3	2.8	0.0	0.0
Santa Fe	7,013	38	53	23.20	30.02	+.04	35.8	+2.7	57	4	46	16	8	25	29	28	18	52	0.30	−0.5	2	4,628	n.	30	nw.	9	14	12	2	3.6	1.2	0.0
Flagstaff	6,907	10	59	23.33	29.99	−.01	35.4	+4.6	58	3	49	14	22	22	36	28	------	59	0.87	------	4	5,205	w.	30	w.	5	20	4	4	------	3.3	T.
Phoenix	1,108	10	82	28.83	30.00	+.01	60.6	+5.5	86	3	76	40	10	45	40	48	36	44	0.02	−0.7	1	3,324	e.	25	w.	21	16	9	3	3.2	0.0	0.0
Yuma	141	9	54	29.85	30.00	.00	61.8	+3.2	83	3	78	40	12	46	39	48	31	36	0.01	−0.6	1	3,457	n.	28	w.	21	17	8	3	2.8	0.0	0.0
Independence	3,957	5	25	26.01	30.07	+.01	48.5	+6.3	72	27	62	24	16	35	39	37	------	------	0.07	−0.7	2	------	nw.	------	------	------	10	10	8	------	0.0	0.0
Middle Plateau							38.7	+5.4										58	1.06	0.0										5.3		
Reno	4,532	74	81	25.46	30.05	−.03	41.4	+5.8	64	27	52	22	15	30	37	34	27	60	1.46	+0.2	9	4,772	w.	42	w.	6	8	11	9	5.4	0.4	0.0
Tonopah	6,090	12	20	------	------	------	39.5	------	56	2	48	22	9	32	22	32	20	46	0.12	------	2	------	se.	------	------	------	------	------	------	------	0.0	0.0
Winnemucca	4,344	18	56	25.61	30.05	−.04	40.2	+6.7	60	27	51	21	28	29	35	34	27	63	0.96	0.0	11	5,733	sw.	31	s.	5	7	8	13	6.1	0.1	0.0
Modena	5,479	10	43	24.62	30.03	−.01	37.6	+6.6	59	3	50	17	16	25	39	31	21	55	0.62	−0.6	6	5,880	w.	37	nw.	6	13	8	7	4.3	1.1	0.0
Salt Lake City	4,360	163	203	25.64	30.06	−.02	40.2	+6.4	60	4	48	16	10	32	25	34	26	58	1.72	+0.3	6	4,321	se.	40	n.	27	10	6	12	5.7	3.7	0.0
Grand Junction	4,602	60	68	25.43	30.08	−.04	34.2	+1.3	53	26	44	17	10	25	26	29	22	64	0.52	−0.1	6	3,184	se.	29	w.	9	8	14	6	5.1	4.7	0.0
Northern Plateau							41.3	+8.3										68	1.06	−0.4										7.3		
Baker	3,471	48	53	26.41	30.04	−.08	37.0	+8.0	51	19	44	22	9	30	24	33	28	71	0.62	−0.7	8	3,816	se.	34	s.	4	4	10	14	6.8	1.2	0.0
Boise	2,739	78	86	27.18	30.08	−.04	42.0	+7.2	58	4	50	26	28	34	26	37	29	62	1.27	−0.2	10	4,313	se.	33	ne.	22	5	11	12	6.2	T.	0.0
Lewiston	757	40	48	29.16	29.98	−.13	44.9	+7.9	61	22	52	28	17	38	27	------	------	------	0.81	−0.5	12	2,611	e.	29	nw.	4	2	4	22	8.5	0.0	0.0
Pocatello	4,477	60	68	25.47	30.06	−.04	36.7	+7.8	53	4	44	10	10	30	23	31	25	65	1.09	+0.2	11	8,226	se.	38	sw.	9	2	15	11	6.7	2.2	0.0
Spokane	1,929	101	110	27.89	29.96	−.13	40.1	+8.8	54	22	46	27	10	34	19	37	33	76	1.59	−0.3	13	4,979	sw.	29	sw.	5	0	6	22	8.6	T.	0.0
Walla Walla	991	57	65	28.89	29.97	−.14	47.0	+9.9	63	3	54	32	10	40	22	42	36	66	1.01	−0.6	11	4,566	s.	27	se.	22	5	8	15	7.0	0.0	0.0
North Pacific Coast Region							45.7	+3.9										83	5.54	+0.5										7.9		
North Head	211	11	56	29.68	29.92	−.14	45.4	+2.4	54	28	49	37	8	42	14	43	41	85	6.19	+0.4	19	13,900	s.	84	s.	1	1	3	24	9.1	0.0	0.0
Port Angeles	29	8	53	------	29.89	------	42.9	------	56	25	48	32	18	37	17	------	------	------	2.62	−0.4	16	4,084	sw.	31	sw.	27	1	7	20	------	0.0	0.0
Seattle	125	215	250	29.81	29.94	−.12	45.6	+4.5	57	1	50	34	19	41	15	42	39	81	4.94	+1.2	18	7,808	s.	47	s.	8	1	9	18	8.1	0.0	0.0
Tacoma	194	172	201	29.71	29.92	−.14	45.2	+4.6	59	1	50	32	19	40	18	------	------	------	4.18	0.0	18	5,954	s.	44	s.	8	1	5	22	8.4	0.0	0.0
Tatoosh Island	86	9	53	29.76	29.86	−.14	44.2	+3.2	52	22	48	36	10	41	10	43	41	87	9.34	+0.6	22	14,098	e.	78	e.	10	2	4	22	8.5	0.0	0.0
Yakima	1,071	5	------	------	------	------	41.4	------	62	3	53	18	17	30	37	------	------	------	0.98	------	7	------	nw.	------	------	------	7	11	10	6.2	0.4	0.0
Medford	1,425	4	------	------	------	------	45.5	------	61	2	54	26	9	37	33	42	38	82	2.07	------	12	------	se.	30	se.	10	3	3	22	7.2	0.0	0.0
Portland, Oreg	153	68	106	29.80	29.96	−.12	46.4	+4.3	60	1	52	34	16	41	20	44	41	82	6.46	+1.0	22	4,495	s.	32	s.	8	1	6	21	8.5	0.0	0.0
Roseburg	510	9	57	29.44	30.00	−.10	47.6	+4.2	65	10	55	31	28	40	28	45	41	79	5.05	+0.5	20	2,226	s.	26	sw.	8	0	10	18	7.4	0.0	0.0
Middle Pacific Coast Region							52.5	+2.7										80	6.06	+2.1										6.6		
Eureka	62	73	89	29.97	30.04	−.07	50.8	+3.6	63	10	57	34	9	44	26	48	44	80	6.49	−0.5	19	5,450	se.	47	se.	10	4	5	19	7.5	0.0	0.0
Point Reyes	490	7	18	29.49	30.01	------	51.6	+2.4	67	28	55	42	9	48	16	------	------	------	6.84	------	16	12,559	s.	74	s.	22	7	6	15	6.6	0.0	0.0
Red Bluff	332	50	56	29.70	30.06	−.05	51.8	+2.4	75	26	59	33	9	45	30	48	44	76	8.39	+4.8	16	5,276	se.	33	se.	7	5	9	14	6.5	0.0	0.0
Sacramento	69	106	117	30.00	30.07	−.02	52.1	+2.0	69	26	58	39	9	46	25	50	47	83	4.45	+1.3	12	5,304	se.	35	se.	8	7	8	13	5.8	0.0	0.0
San Francisco	155	208	243	29.90	30.07	−.03	55.2	+3.0	72	27	60	46	9	50	21	51	48	80	7.90	+4.2	14	4,747	sw.	36	sw.	22	8	6	14	6.6	0.0	0.0
San Jose	141	12	110	29.94	30.09	------	53.6	+3.0	74	27	63	36	25	45	34	------	------	------	3.09	+0.6	13	4,527	se.	37	se.	7	6	6	16	6.8	0.0	0.0
South Pacific Coast Region							56.2	+2.6										75	1.64	−0.8										5.4		
Fresno	327	89	98	29.73	30.09	+.01	54.4	+3.3	73	11	64	36	25	45	26	50	46	76	1.43	+0.1	11	3,359	nw.	24	se.	11	11	8	9	5.2	0.0	0.0
Los Angeles	338	159	191	29.70	30.07	+.01	57.7	+2.2	82	28	66	43	2	50	28	50	45	71	0.53	−2.4	6	3,058	e.	15	ne.	11	11	9	8	5.0	0.0	0.0
San Diego	87	62	70	29.98	30.07	+.01	56.6	+1.5	80	27	64	43	4	49	29	51	48	81	0.30	−1.7	5	3,467	nw.	22	w.	20	6	13	9	5.9	0.0	0.0
San Luis Obispo	201	32	40	29.88	30.10	−.01	56.3	+3.2	80	28	65	40	16	47	30	50	45	72	4.32	+0.7	11	2,867	n.	19	ne.	25	8	11	9	5.4	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.92	30.00	------	73.4	−1.5	85	12	79	64	5	68	17	------	------	------	4.11	+1.6	17	6,916	e.	38	e.	16	14	10	4	4.1	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	29.76	29.89	.00	78.6	−1.6	90	23	88	67	2	69	22	71	69	85	0.07	−0.7	1	6,845	nw.	28	nw.	13	5	23	0	4.9	0.0	0.0
Colon	36	7	97	29.87	29.90	.00	80.0	0.0	86	15	85	72	8	76	13	73	71	82	0.73	−0.9	9	10,492	n.	27	nw.	12	10	15	3	4.9	0.0	0.0
Alaska																																
Juneau	80	11	54	------	------	------	27.2	------	41	28	32	4	1	22	19	25	20	74	3.69	------	14	5,543	s.	38	e.	1	6	4	18	7.1	25.6	10.4

TABLE 2.—*Data furnished by the Canadian Meteorological Service, February, 1925*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*°F*	*°F*	*°F*	*°F*	*°F*	*°F*	*In.*	*In.*	*In.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48												
Halifax, N. S.	88												
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38												
Chatham, N. B.	28												
Father Point, Que.	20	29.96	29.99	+.01	15.1	+3.6	20.8	9.4	47	−6	3.08	+0.87	16.0
Quebec, Que.	296	29.66	30.00	+.01	19.2	+7.4	25.6	12.8	38	−4	5.04	+1.77	33.8
Montreal, Que.	187												
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.72	30.00	−.02	22.3	+10.6	30.8	13.8	47	−10	3.36	+0.67	7.0
Kingston, Ont.	285												
Toronto, Ont.	379	29.58	30.01	−.03	27.8	+6.3	34.5	21.0	50	2	3.60	+0.99	9.6
Cochrane, Ont.	930				5.0		14.8	−4.8	42	−30	0.30		2.0
White River, Ont.	1,244												
Port Stanley, Ont.	592												
Southampton, Ont.	656	29.24			24.3	+4.4	31.2	17.5	50	−10	2.21	−0.69	13.1
Parry Sound, Ont.	688	29.25	29.98	−.03	20.3	+6.0	27.9	12.7	52	−15	2.16	−0.76	16.3
Port Arthur, Ont.	644	29.25	29.99	−.06	10.8	+4.4	18.5	3.1	42	−20	0.60	−0.30	6.0
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.13	30.06	−.03	1.5	+4.2	10.8	−7.8	37	−38	0.41	−0.20	4.1
Le Pas, Man.	860												
Qu'Apelle, Sask.	2,115	27.65	30.02	−.06	7.3	+7.9	17.5	−2.9	42	−33	0.93	+0.20	9.3
Medicine Hat, Alb.	2,144												
Moose Jaw, Sask.	1,759				12.6		20.6	4.6	47	−34	0.23		2.1
Swift Current, Sask.	2,392	27.34	29.97	−.10	16.4	+8.4	24.4	8.5	42	−23	0.22	−0.52	2.2
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Edmonton, Alb.	2,150												
Prince Albert, Sask.	1,450	28.43	30.10	+.01	0.4	+3.4	11.9	−11.2	40	−47	0.33	−0.36	3.3
Battleford, Sask.	1,592	28.21	30.06	−.03	2.7	+2.6	12.0	−6.5	42	−36	0.60	+0.23	6.0
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.63	29.89	−.11	44.2	+4.7	48.5	40.0	54	36	2.39	−1.71	T.
Barkerville, B. C.	4,180												
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.99	30.16	+.05	64.9	+3.4	70.7	59.0	75	53	9.15	+4.71	0.0

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Winnipeg, Man.	760	29.24	30.14	+.03	0.4	+7.2	8.0	−7.1	34	−26	1.60	+0.72	16.0
Minnedosa, Man.	1,690	28.14	30.07	−.03	−1.1	+6.1	8.0	−10.2	39	−33	1.42	+0.62	14.2
Kamloops, B. C.	1,262	28.66	30.01	+.05	19.0	−4.0	25.5	12.6	47	0	1.82	+1.00	18.2
Barkerville, B. C.	4,180	25.40	29.82	−.08	18.1	+0.3	23.8	12.4	35	−7	3.55	+0.95	35.5

| | | |

Chart II. Tracks of Centers of Cyclones, February, 1925. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by Wilfred P. Day)

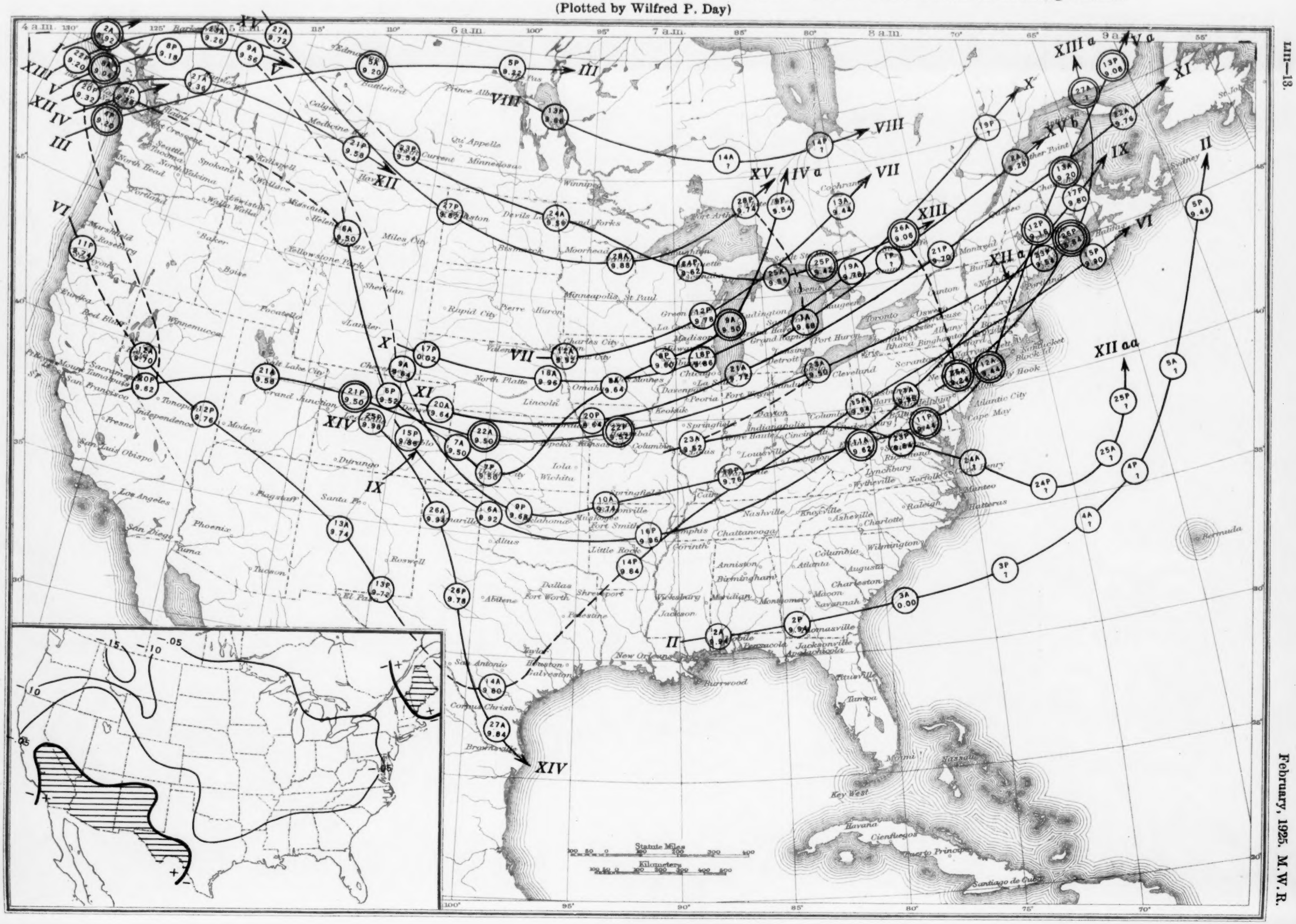

Chart III. Departure (°F.) of the Mean Temperature from the Normal, February, 1925

Chart III. Departure (°F.) of the Mean Temperature from the Normal, February, 1925

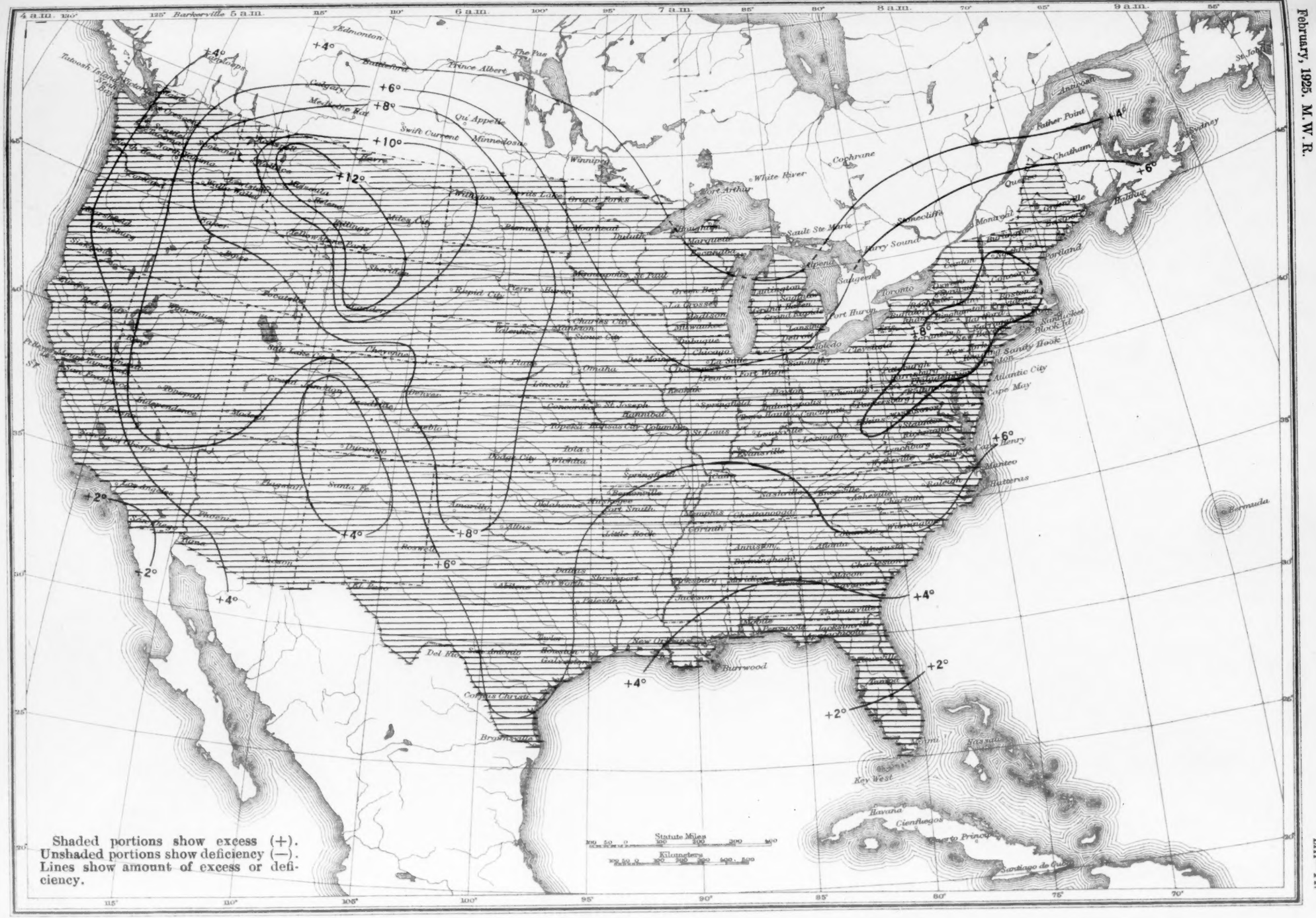

Chart IV. Total Precipitation, Inches, February, 1925. (Inset) Departure of Precipitation from Normal

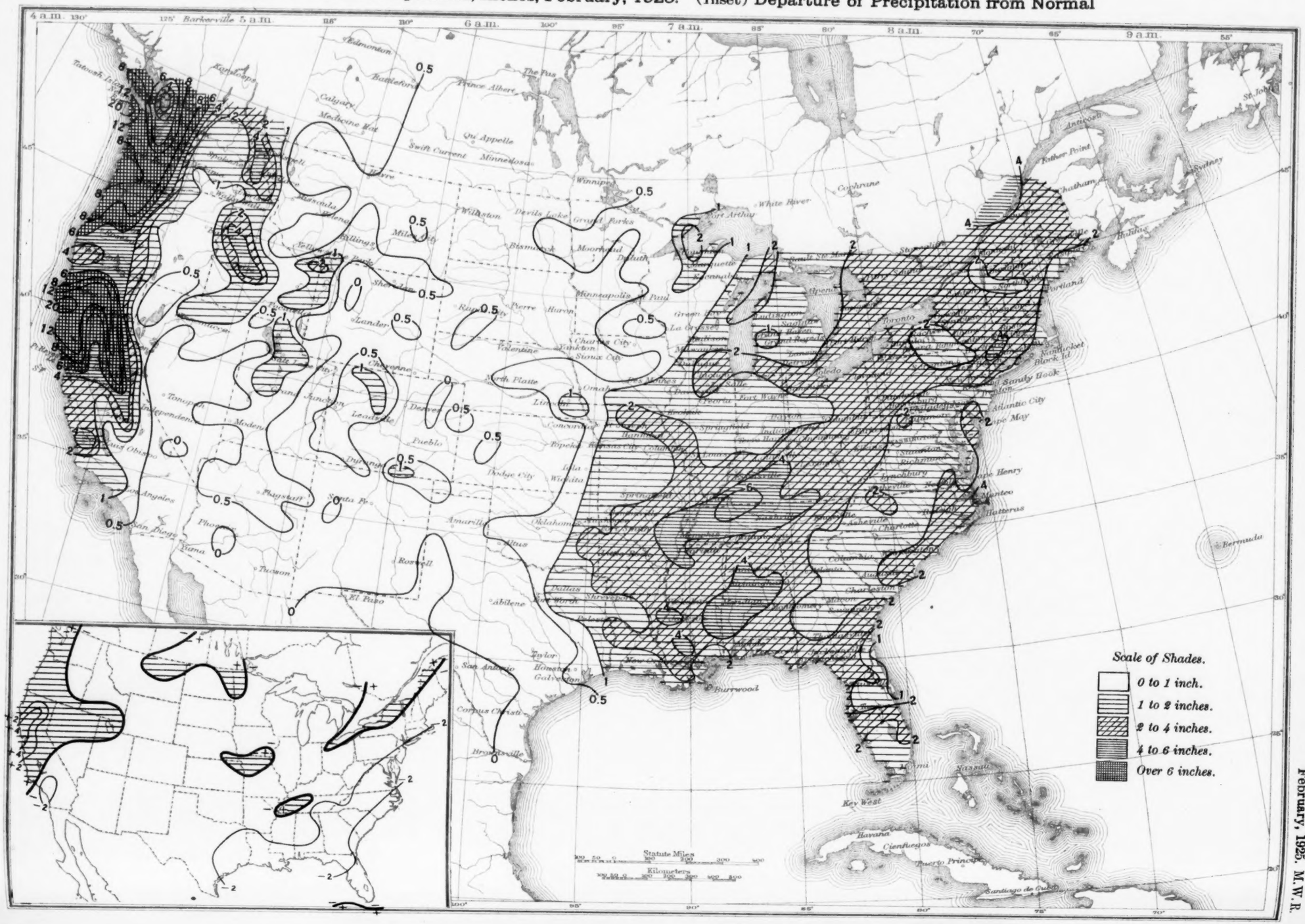

Chart V. Percentage of Clear Sky between Sunrise and Sunset, February, 1925

Chart V. Percentage of Clear Sky between Sunrise and Sunset, February, 1925

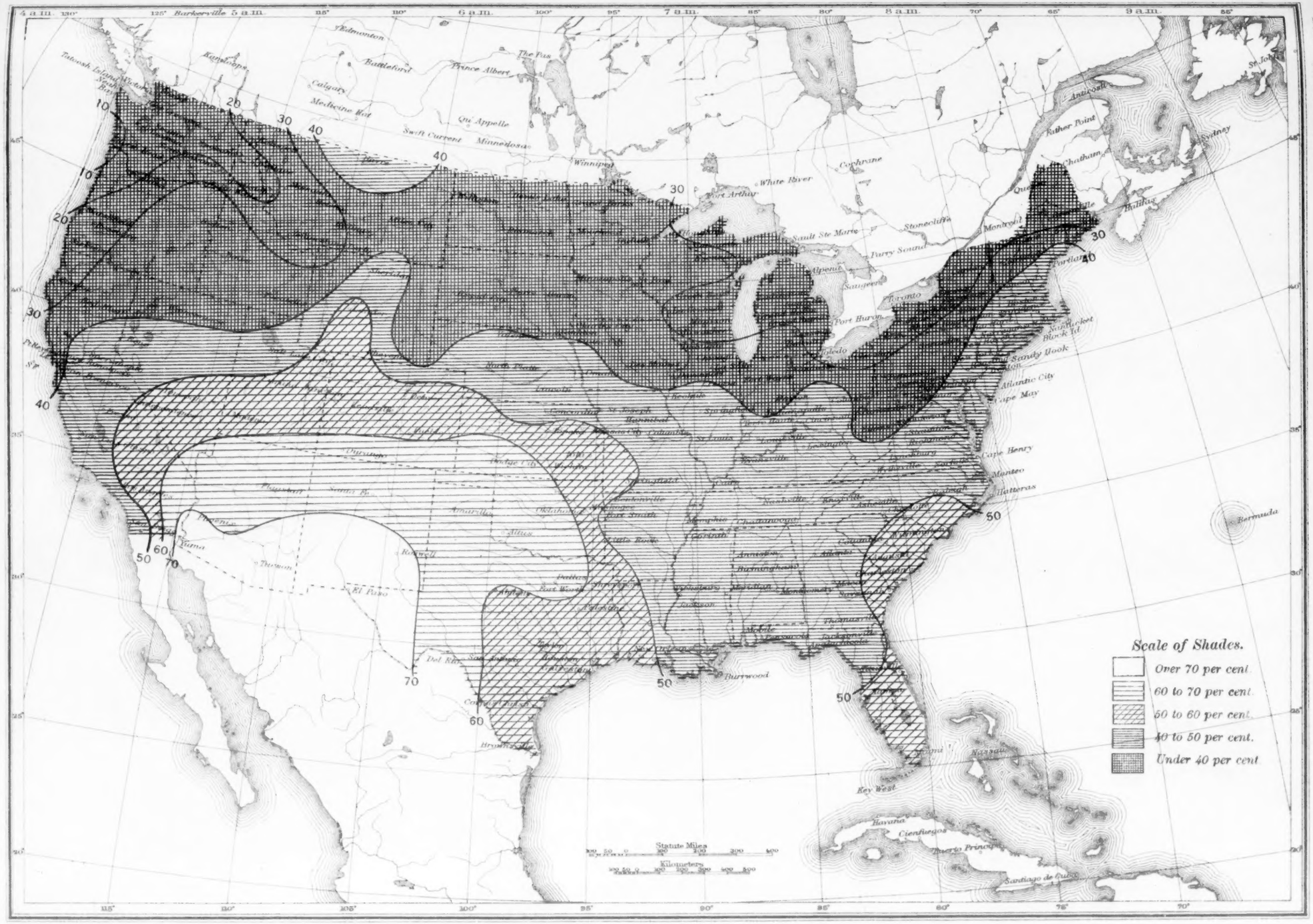

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, February, 1925

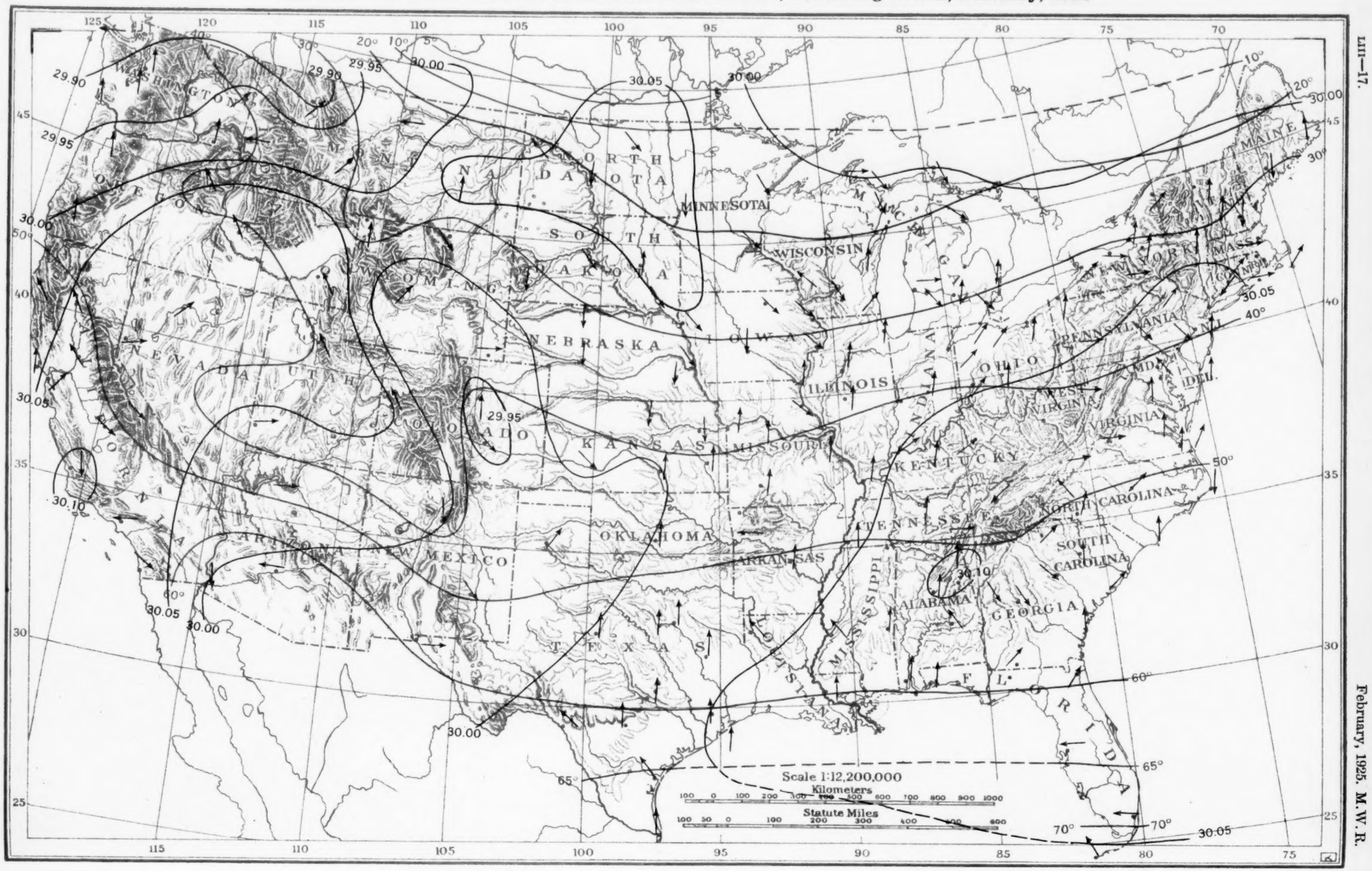

Chart VII. Total Snowfall, Inches, February, 1925. (Inset) Depth of Snow on Ground at end of Month

Chart VII. Total Snowfall, Inches, February, 1925. (Inset) Depth of Snow on Ground at end of Month

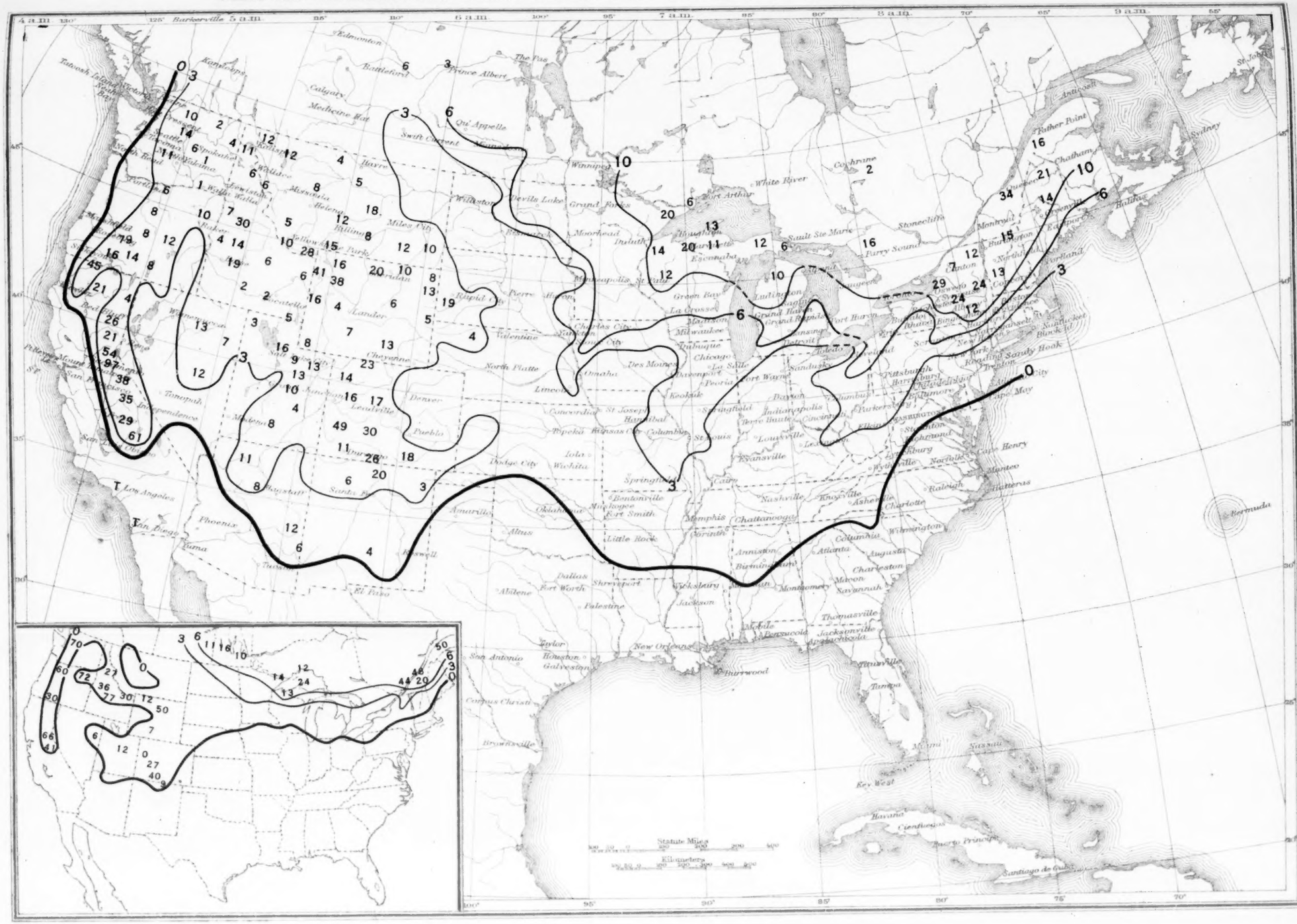

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Chart VIII. Weather Map of North Atlantic Ocean, February 10, 1925

(Plotted by F. A. Young)

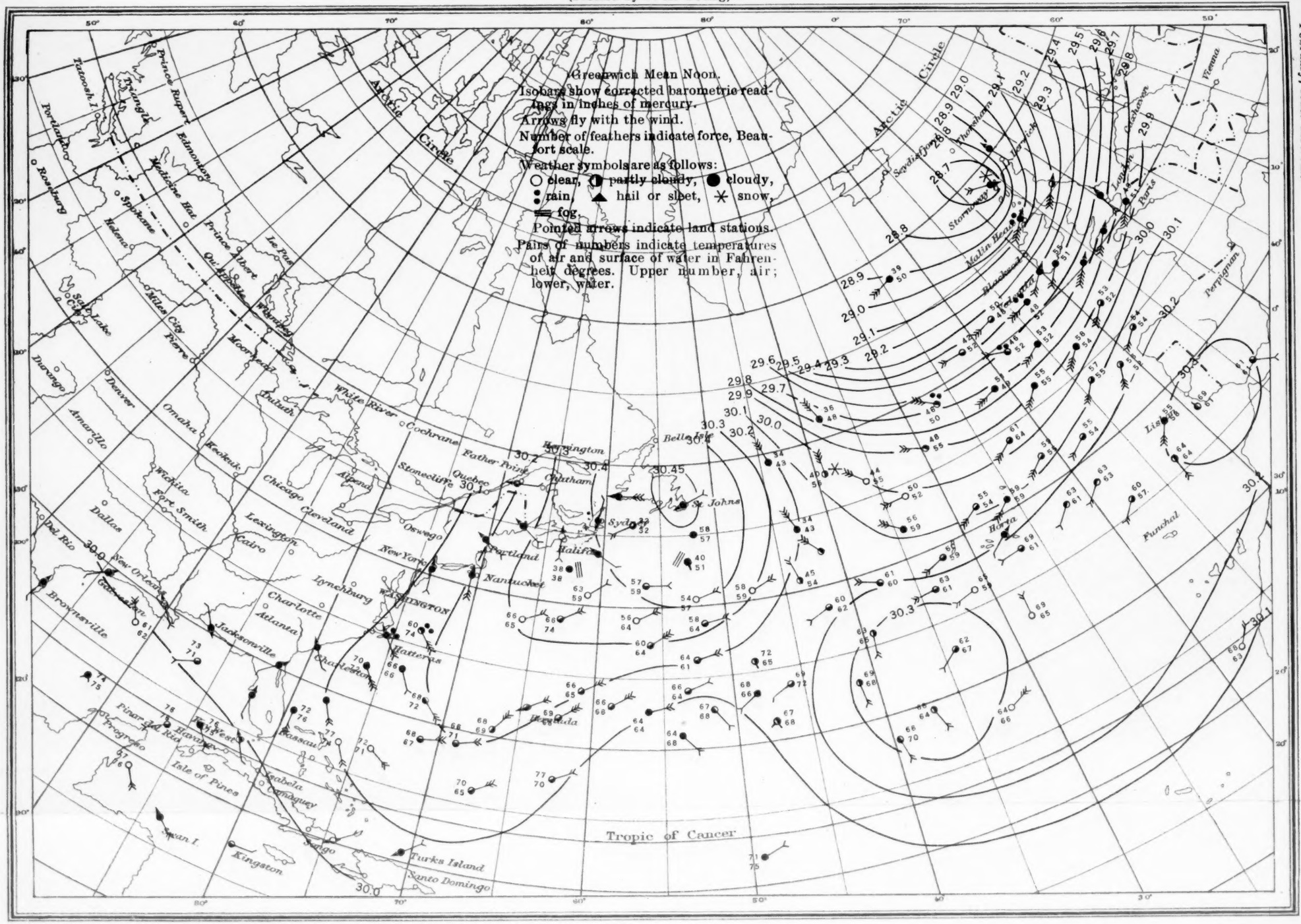


Chart IX. Weather Map of North Atlantic Ocean, February 11, 1925

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, • rain, ▲ hail or sleet, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

Arctic Circle

Tropic of Cancer

Chart X. Weather Map of North Atlantic Ocean, February 12, 1925

(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, February 12, 1925
(Plotted by F. A. Young)

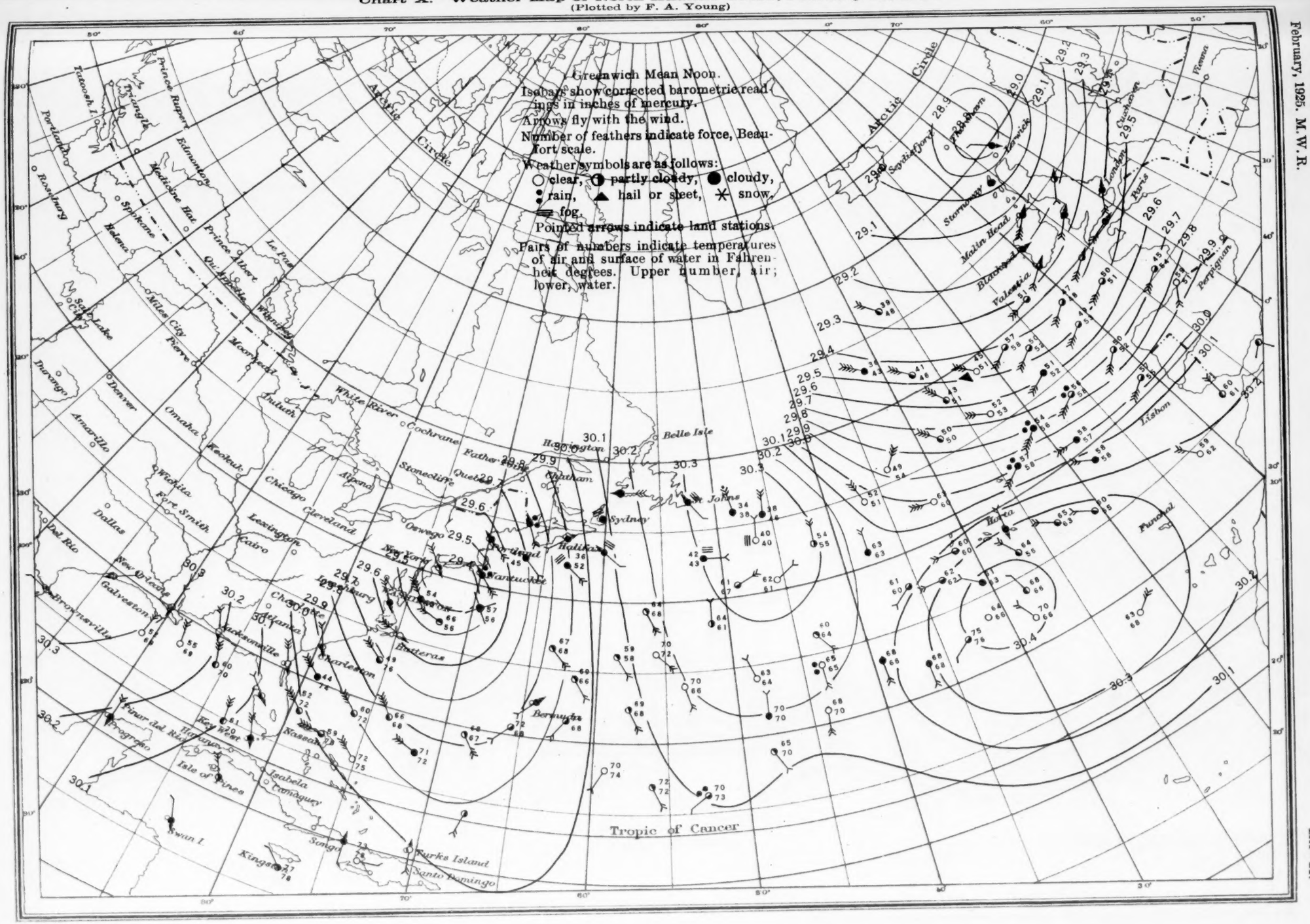


Chart XI. Weather Map of North Atlantic Ocean, February 13, 1925

(Plotted by F. A. Young)

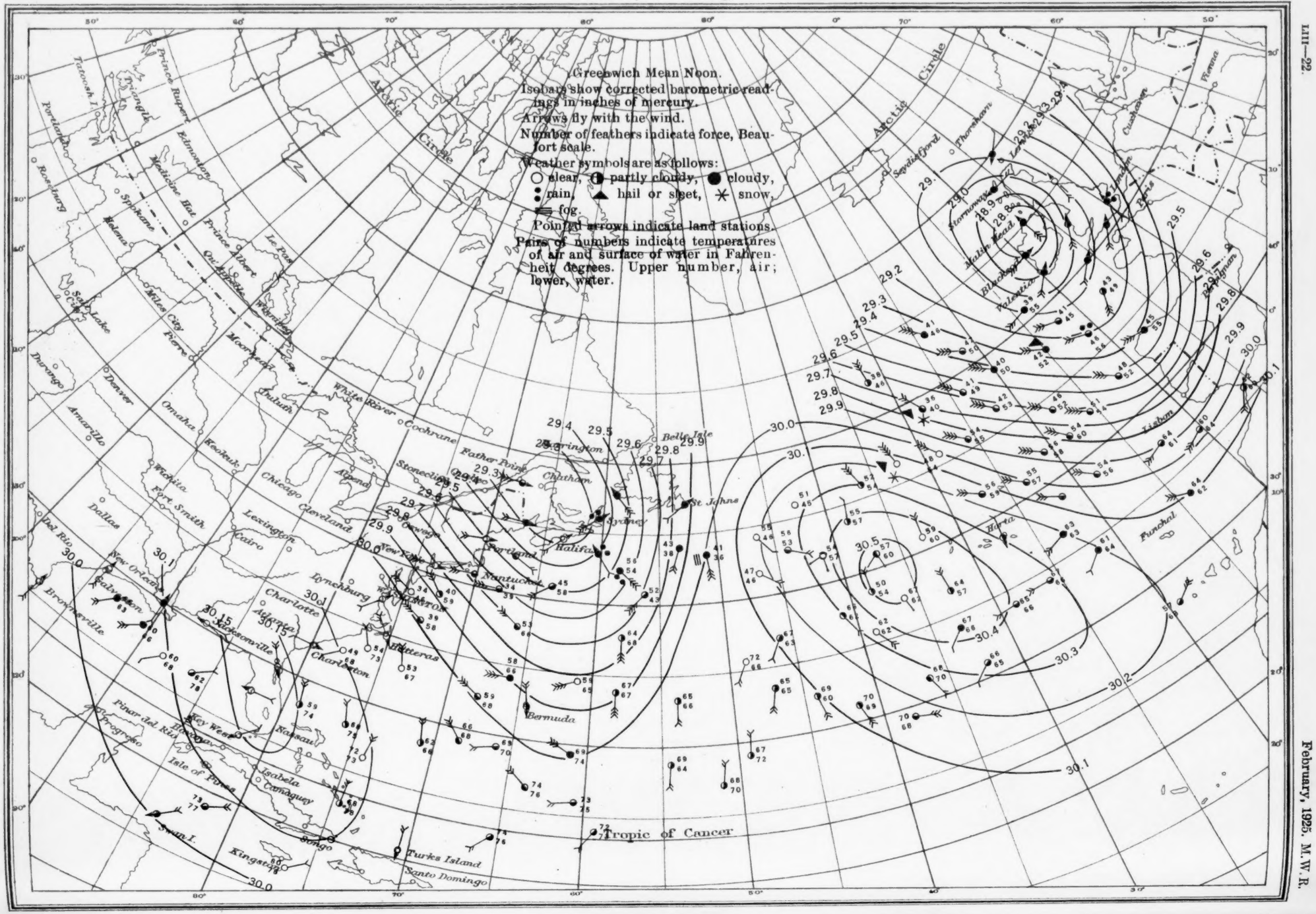


Chart XII. Weather Map of North Atlantic Ocean, February 14, 1925

(Plotted by F. A. Young)

Chart XII. Weather Map of North Atlantic Ocean, February 14, 1925

(Plotted by F. A. Young)

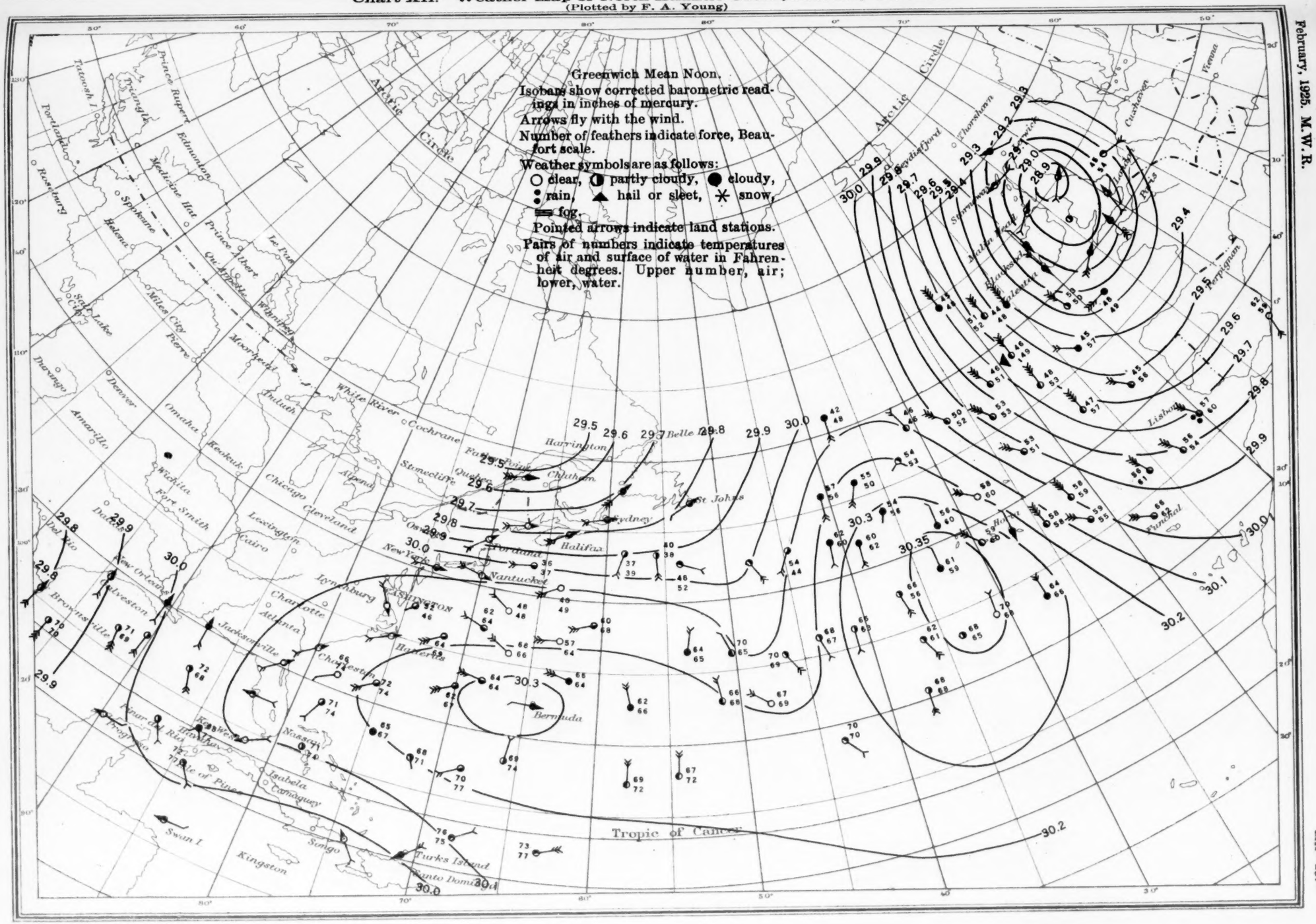
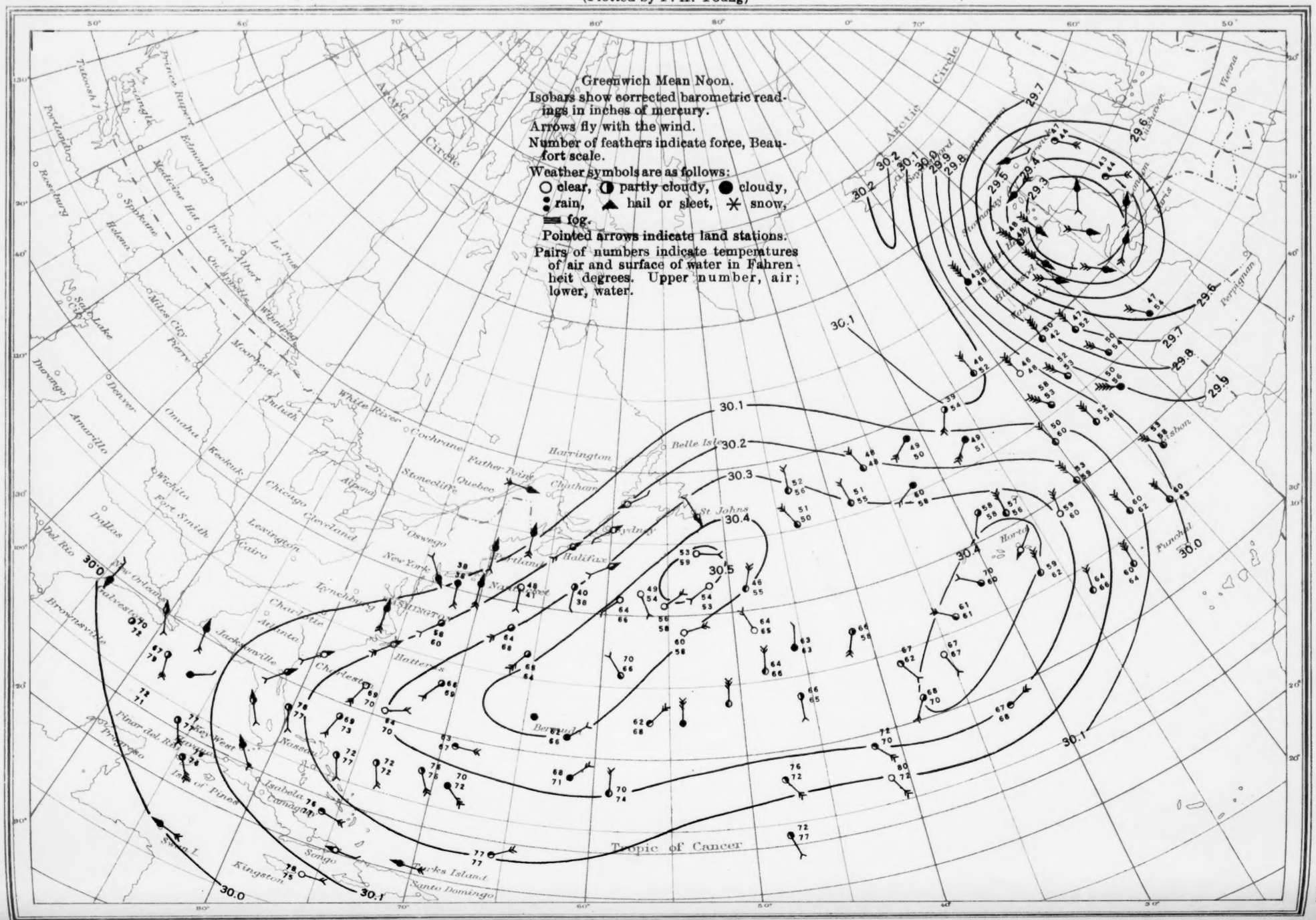


Chart XIII. Weather Map of North Atlantic Ocean, February 15, 1925

(Plotted by F. A. Young)